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

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CHAPTER I

INTRODUCTION

The art of teaching is of ancient lineage and the need for improving the teaching process has long been the concern of educators. In past years much time and effort has been spent in trying to determine the variables associated with good teaching as well as attempting to identify the characteristics of a good teacher.

Research on the teaching act during the last fifty years has been dominated by studies of teacher personality characteristics and their relationship to teaching effectiveness. Two bibliographies by Domas and Tiedeman (10) and Barr (6) reported well over 1,000 such studies. After an analysis of numerous studies of teacher characteristics, Getzels and Jackson (15, p. 574) concluded:

> Despite the critical importance of the problem and a half-century of prodigious research effort, very little is known for certain about the nature and measurement of teacher personality, or about the relation between teacher personality and teaching effectiveness.

According to Barr (5) the large number of studies on measurement of teacher characteristics and the prediction of teaching efficiency have produced experimental results that have been inconclusive. Biddle (8, p. 3) supported this viewpoint when he stated:

> The bulk of studies on teacher effectiveness to date have produced negligible results. Further, until a great deal is known about classroom interaction, the bulk of educational theories must be judged 'untested.'

B. O. Smith (25, p. 326) further stated:

> For almost four decades we have been making study after study in our attempt to measure teacher effectiveness. In all our studies we proceeded as if we knew already what teaching is and that all we had to do was give tests to find out its effects. Increasingly during the past decade, studies of teaching have been abandoning efforts to find out the effectiveness of teaching, and have concentrated instead upon analysis of teaching, . . .

A survey of recent educational literature reflects that more and more attention is being given to the study of the behavior of teachers while they teach and pupils as they learn in the classroom. This process of measuring classroom behavior through systematic observation is the most obvious approach to research on teaching. Medley and Mitzel (21, p. 249) seemed to infer this when they stated:

> The role of direct observation in research on teacher effectiveness would seem to be a means of learning something about the teaching process and its relationship to pupil learning.

Thus, in the past decade there has been an intensive effort to develop devices to measure the characteristics of interaction between teacher and pupils in the classroom.

Justification for the Study

The development of schemes for systematic observation of classroom behaviors has produced considerable information about the behaviors of pupils and teachers as they interact in the classroom. Amidon and Simon (2, p. 130) 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.

Amidon (1, p. 94) further concluded that:

> 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 related to pupil outcomes. There may be particular patterns that are appropriate for teaching certain subject matters.
> 3. There appears to be certain behaviors that characterize good teachers (in terms of pupil achievement) regardless of the subject matter being taught.

Medley and Mitzel (21) emphasized the fact that research should be conducted which attempts to identify patterns of behaviors that distinguish between effective and ineffective teachers. The Committee on Criteria of Teacher Effectiveness (23) listed changes in pupil behavior as one of the most important components of teacher effectiveness. Barr (5, p. 13) supported this premise when he stated:

> A fourth type of criterion of teacher effectiveness is that of pupil growth and achievement, which is usually expressed as pupil gain scores based upon achievement tests administered prior to instruction and again at some subsequent date when a particular unit of instruction or course has been completed. To most persons this criterion is considered a primary criterion against which all other criteria should be validated.

Hence, it seems that teacher effectiveness must ultimately be defined in terms of changes in pupil behavior. Medley and Mitzel (21) indicated that the ultimate objective of changing pupil behaviors can only be reached through changing the behaviors of the teachers while they teach. They further pointed out that it is impossible to determine if teachers are behaving in certain ways without observing them while they teach.

Thus, it appears that more should be known about the relationship of certain teacher behaviors and their effects upon achievement of pupils.

Statement of the Problem

This study will attempt to provide answers to the following questions. Do definite patterns of teacher-pupil interaction exist in the elementary mathematics classroom which show a high degree of relationship to student achievement in mathematics? If teacher-pupil interaction patterns exist, will the Wright-Proctor Observational Instrument (33) detect these patterns?

The purpose of this study, therefore, is to attempt to identify characteristics of teacher-pupil interaction in the classroom setting, as measured by the Wright-Proctor Observational Instrument (33), that demonstrate a high degree of correlation with the average pupil gain scores, as measured by the arithmetic subtests of the Stanford Achievement Test (20).

Basic Hypotheses

This study proposes to establish a basis for the testing of the following null hypotheses:

1. a) There is no significant correlation between the fifth grade mean pupil gain scores on the arithmetic computation subtest of the Stanford Achievement Test (20) and the total frequency of teacher behaviors classified as a given category of the Wright-Proctor Observational Instrument (33).

b) There is no significant correlation between the fifth grade mean pupil gain scores on the arithmetic computation subtest of the Stanford Achievement Test (20) and the total frequency of pupil behaviors classified as a given category of the Wright-Proctor Observational Instrument (33).

2. a) There is no significant correlation between the fifth grade mean pupil gain scores on the arithmetic concepts subtest of the Stanford Achievement Test (20) and the total frequency of teacher behaviors classified as a given category of the Wright-Proctor Observational Instrument (33).

b) There is no significant correlation between the fifth grade mean pupil gain scores on the arithmetic concepts subtest of the Stanford Achievement Test (20) and the total frequency of pupil behaviors classified as a given category of the Wright-Proctor Observational Instrument (33).

3. a) There is no significant correlation between the fifth grade mean pupil gain scores on the arithmetic application subtest of the Stanford Achievement Test (20) and the total frequency of teacher behaviors classified as a given category of the Wright-Proctor Observational Instrument (33).

b) There is no significant correlation between the fifth grade mean pupil gain scores on the arithmetic application subtest of the Stanford Achievement Test (20) and the total frequency of pupil behaviors classified as a given category of the Wright-Proctor Observational Instrument (33).

Definition of Terms

Teacher-Pupil Interaction.--Those statements and questions presented by the teacher or pupil and the resultant responses from the students or teacher.

Average Pupil Gain Score.--The mean of the achievement test scores for a given arithmetic subtest of the Stanford Achievement Test (20) for a given class.

Independent Variables.--The independent variables are the categories of the Wright-Proctor Observational Instrument (33).

Dependent Variables.--The dependent variables are the arithmetic achievement gain scores.

Intervening Variables.--The intervening variables are the two observers that collected data in this study.

Major Assumptions

For the purpose of this study the following assumptions have applied:

1. The Wright-Proctor Observational Instrument (33) provides a systematic method for classification of teacher-pupil interaction in the elementary mathematics classroom.

2. The activities of the observers in the classrooms did not appreciably change the patterns or frequency of the teacher-pupil interactions during the observation periods.

3. The primary acts of influence of a teacher are expressed through verbal statements.

4. The teacher in a given classroom can control the verbal participation in the classroom by her actions and behaviors.

5. The amount and type of teacher talk determines the verbal behavior of the pupils.

Procedures and Analysis of Data

For the purpose of this study the following delimitations have applied:

1. Four elementary schools in the Tulsa Public School System were selected and the eight fifth-grade teachers in these schools were the sample for this study.

2. The student population consisted of children in Grade 5 in the four selected elementary schools in the Tulsa Public School System.

3. The eight teachers were observed ten times for thirty minutes each visit and the teacher-pupil verbal interactions were categorized using the Wright-Proctor Observational Instrument (33).

4. The evaluation of differences in patterns and frequencies of teacher-pupil interactions in the classroom was limited to differences in observable, recorded teacher-pupil interactions in those classes observed.

5. The conclusions which have been drawn from the results of this study were limited to specific statements concerning the degree of correlation between the independent and dependent variables as shown by the data of this study, performed under the conditions operating at the time the study was made.

6. Classes were not observed during a class period which was being used as a testing session or immediately prior to or following a school holiday, all school activity, or a school assembly.

7. The scores on the arithmetic subtests of the Stanford Achievement Test (20) were used to determine the average pupil gain score for each class observed.

8. Analysis of data was made through the use of the Spearman method of rank-difference correlation (17).

Data and Instrumentation

The procedures used in collecting the data for this study followed the sequence as presented below:

1. The four elementary schools used in this study were selected on the basis of average I.Q., achievement, and the stability of the surrounding community. The selection process is described in detail in Chapter IV.

2. An interview was arranged with the principals and fifth-grade teachers of the four schools explaining the study and asking for their cooperation.

3. Initial periods of familiarization were planned for each teacher so that the teacher and students would become accustomed to the two observers.

4. Each teacher was observed ten times for thirty-minute intervals and the verbal interactions in the classroom were categorized using the _Wright-Proctor Observational Instrument_ (33).

5. A schedule was established so that both observers could observe the same class during the same period for the purpose of checking observer reliability.

6. A final report of the data gathered was prepared.

Selection of Instrument

The _Wright-Proctor Observational Instrument_ (33) was selected for use in this study since it was specially designed for direct observation of verbal interaction of teachers and pupils in the mathematics classroom. The Wright-Proctor instrument views the study of verbal behaviors from three frames of reference: mathematical content, psychological process, and sociological attitudes. The three frames of reference are viewed simultaneously. Each of the frames has several categories.

<u>Mathematical Content</u>

1. Fundamentals: Structure, Technique
2. Relations: Deductive, Inductive, Statement
3. Applications: 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 which concern nonmathematical matters 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 explained in detail in Chapter III.

Organization of the Data

The statistical analysis of the data resulting from the use of the <u>Wright-Proctor Observational Instrument</u> (33) encompassed a measure of the intensity of association of the independent and dependent variables.

The statistical technique used was the Spearman method of rank-difference correlation (17). The level of confidence was set at the .05 level. The following formula for the Spearman rank-difference coefficient of correlation was used (17, p. 306):

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

N is the number of pairs of measurements and D^2 is the sum of the squared differences between ranks. A discussion of the calculation of r_s where tied ranks occur is given in Appendix B.

Format of Succeeding Chapters

In this chapter the writer has developed the background for the problem, stated the problem, shown a need for the study, explained the procedures and instrumentation, and given a brief description of the instrument and the statistical techniques used in analyzing the data.

Chapter II is a discussion of the review of related literature. Chapter III is a discussion of the instrumentation of the study. The content of Chapter IV includes a description of the subjects and the general methodology of the study. This chapter also includes a presentation and analysis of the data obtained from this study.

In Chapter V the writer summarizes results, conclusions, and recommendations for further study.

CHAPTER II

REVIEW OF RELATED LITERATURE

Attempts to relate teacher characteristics or teaching methods to pupil measures have a long history in education. That most of the research has been unproductive attests to the complexity of the problem. The practical problem of studying the complex process of the teaching act diverted investigators from the behavioral aspects and inclined them to use some type of rating scale or various other predictors of teaching success.

Within the past decade or so there has been a shift in the direction of educational research on the part of some investigators. The focus of inquiry has become what actually happens in the classroom while the teacher is teaching and the pupils are learning. This type of research attempts to describe, through systematic analysis, what a teacher does and how he behaves while teaching.

Interest in this type of research has produced experimental studies that involve the observation of the interaction between the teacher and pupil during the teaching process. The result is that there are now available a variety of instruments for analyzing the teacher-pupil behaviors in the classroom. The Wright-Proctor Observational Instrument (33) is one such instrument.

For the reader to thoroughly understand this study and the description of the instrument given in Chapter III, he must have some knowledge of the developmental process of studies involving observation instruments and the previous research conducted with these instruments.

Although the studies involving systematic classroom observation differ widely in many aspects, they reflect a common research orientation. The manner in which behaviors are categorized and the types of behaviors that are categorized reflect the investigator's intended purpose or his orientation. Systems for classification of teacher-pupil interactions thus far developed can be divided into three major categories: affective systems, cognitive systems, and multidimensional systems.

Affective Systems

Affective systems for observing teacher-pupil interaction involve what is often termed the classroom or psychological climate. Classroom or psychological climate refers to the attitudes of the class toward the teacher and the teacher toward the class.

Most of the studies on classroom climate trace their origin to the work of Anderson and Brewer (3). Anderson and Brewer identified and measured with reliability patterns of "dominative" and "socially integrative" teacher behaviors. They found that those teachers whose functional relations with the children were predominantly "integrative" in nature had classrooms in which children showed more spontaniety and initiative. When domination prevailed children were observed to be less responsive to the classroom situation.

Withall (30) developed a system for categorizing verbal statements made by the teachers. His system encompassed seven categories for teacher statements: learner-supportive, acceptant, problem structuring, neutral, directing, and self-supporting. These categories comprised the Social-Emotional Climate Index which was designed to reflect the degree to which verbal behaviors were "learner-supportive" or "teacher-supportive." Withall concluded that when teacher-centered patterns were continued they produced anxiety and reduced pupil's ability to recall the material studied. The reverse trends were noted in student reactions to learner-centered teaching.

The most intensive research program involving the psychological dimension of the classroom teaching has been conducted by Flanders (12, 13, 14). Flanders' original investigation used the Withall system of classification. Subsequent research (13, 14) was directed toward describing the effects of teaching behaviors on the classroom climate and learning goals. He devised an instrument which includes ten categories. Seven of the ten categories describe teacher behaviors: accepting feelings, praising and encouraging, using student ideas, asking questions, lecturing, giving directions, and criticizing or justifying authority. The first four he identified as "indirect" teacher influence, that is, an influence which tends to increase the freedom of the pupils. The remaining categories refer to what Flanders called "direct" teacher influence. He defined "direct" teacher influence as the influence which tends to increase the control of the teacher by restricting the freedom of the students. Categories eight and nine describe pupil behavior and the last category is used to record silence or confusion.

Using Flanders' system, the observer in the classroom classifies the verbal behaviors of the teacher at the end of each three second interval. The "indirect" and "direct" influence can be determined by summarizing the frequency and types of the observed classifications into an interaction analysis matrix.

Flanders (13) compared the patterns of verbal teacher behavior of 16 eighth-grade mathematics and 16 seventh-grade social studies teachers. Flanders found that the students in the indirect classes achieved more than students in direct classrooms in both mathematics and social studies. He also found that differences were even greater between classes consistently exposed to indirect and direct patterns of teaching. A third finding was that indirect teachers are more flexible. They tend to begin a topic with a higher proportion of indirect influences and then become more direct as they progress toward a goal. 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. Flanders' study also 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 5 to 6 times as much acceptance of student ideas and encouraging of ideas; they also used 5 to 6 times less direction and criticism of students, talked 10 per cent less, and encouraged 2 to 3 times as much student-initiated talk.

Marie Hughes (19) made an intensive analysis of the classroom behaviors of 35 elementary teachers in eight different school districts in two western states. Hughes' study was similar to Flanders' study in that it analyzed teaching in terms of degrees of control and freedom in the classroom. This study grew out of an in-service investigation designed to determine a sound basis for a merit pay system. Thus, the primary purpose was to define and describe "good" teaching. The subjects for the study were 25 teachers selected from a group of 40 teachers judged "good" by the county supervisory staff. The other group of 10 teachers was selected as being representative of the 25 teachers in that school.

Hughes' system of categorization, the "Provo Code," was developed from an analysis of actual teaching of some 60 teachers in both elementary and secondary schools. The code categorizes 31 separate teacher or pupil functions. The instrument is divided into three broad classifications: "Positive Affectivity" which represents those times when the teacher uses supportive statements or offers help to a pupil; "Negative Affectivity" which represents those times when the teacher uses reprimands, threatens, punishes, etc.; and "Development of Content" which refers to occasions when a teacher responds to a pupil's activity by accepting, by clarifying, and by evaluating.

Hughes found that primary teachers were more controlling and more negative than middle or upper grade teachers. The primary teachers performed a larger number of total teaching functions than the intermediate teachers. Her analysis also revealed that the most frequent function performed by the teacher was "controlling." The category of "controlling" refers to such things as the teacher setting standards, structuring, or in some way organizing the classroom. There was an extremely low use of functions that were categorized as "development of content." Another significant finding revealed that there was no significant difference between the group of teachers judged "good" and the representation group. Also noteworthy is the finding that there was no difference in the groups in functions categorized as "Positive Affectivity."

Cognitive Systems

Cognitive systems for observing teacher-pupil interaction involve categorizing various aspects of intellectual skills. These skills include the ability to recall or recognize facts, definitions, laws, and also the ability to analyze, evaluate, synthesize, and interpret.

In the last few years there have been major efforts to relate teaching behaviors to achievement of cognitive objectives. Aschner and Gallagher (4) developed a cognitive system for classifying verbal behaviors in the classroom. The development of this instrument was greatly influenced by Guilford's concept of the "structure of intellect" (16). Four of Aschner's five primary categories represent Guilford's theory of thinking operations: cognitive-memory, convergent thinking, divergent thinking, and evaluation thinking. The fifth category, routine, encompasses various interactions that occur in a classroom that are not directly related to the cognitive domain.

Gallagher (15) used this instrument in his study of gifted children. He was particularly interested in developing the productive and creative aspects of intellectual activity. The instrument was developed with Aschner's help to describe the amount and quality of productive thinking that gifted children do during the sequence of a class discussion at the junior high school level. Aschner and Gallagher (4) found that, in terms of frequency of occurrence, the categories routine and cognitive-memory occurred most often. Next came convergent thinking, then evaluative thinking, and finally, least often, divergent thinking.

Still another approach to the study of teaching behaviors was reported by Smith and Meux (26); they were the first investigators to carefully consider the logical aspects of the teaching act. They used tapescripts as a method of recording classroom transactions and developed a set of thirteen categories to accomplish the task of identifying and describing 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. Smith and Meux 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 were employed from teacher to teacher, and from content area to content area. Noteworthy was the finding that mathematics was high in stating and normative explaining while low in opining and evaluating.

Taba and her associates (28) were concerned with developing a concept of thinking and devising an instrument by which certain cognitive processes could be measured, analyzed, and observed. In this initial study, Taba devised a coding system to analyze recordings of class sessions. This instrument was designed to provide a means to trace patterns of development of cognitive skills as they develop in the classroom. This study, Thinking in Elementary School Children (28), established the concept of cognitive tasks as a central focus for organizing cognitive skills which allowed Taba to study teaching strategies in a succeeding investigation (29).

This second study was somewhat different in that Taba was interested in assessing 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. The results of this study were reported in terms of changes in the measure of cognitive skills. A most important finding was that the most marked single influence on cognitive performance in children resided in the impact of teaching strategies employed by the teacher. In other words, the whole pattern of teacher behavior determines the level of response attained in learners.

Arno Bellack and his associates (7) conducted an investigation into the linguistic behaviors in the classroom. Their study was essentially a study of the roles that the teacher and pupils play while engaged in the game of teaching and learning. Bellack developed a system for categorizing specific functions of language.

In the game of teaching, Bellack conceived of four basic verbal maneuvers which describe what teachers and pupils do while they play the game. These maneuvers are called "pedagogical moves" and are described as structuring, soliciting, responding, and reacting moves. Bellack found that the ratio of teacher to pupil lines spoken was 3 to 1. He also found that the teaching roles of the classroom are clearly delineated for both teachers and pupils. Teachers are responsible for structuring the lesson, while the pupils' primary task is to respond to the teacher's solicitation. Thus, structuring, soliciting, and reacting were teacher functions while responding was the corresponding pupil function.

Multidimensional Systems

There have been a number of attempts to measure multidimensional aspects of the classroom. Cornell, Lindvall, and Saupe (10) developed an observation system for measuring a number of dimensions of classroom behavior. This device provides a measure of the extent to which provisions were being made for: individual difference, initiative, content, variety, competency, and classroom climate.

Medley and Mitzel (21) combined the Cornell system (10) with the Withall system (30) to develop an instrument entitled the Observation Schedule and Record (OScAR). The development of the OScAR grew out of a desire to study the performance of beginning teachers. The OScAR is a device designed to provide measures of teacher behaviors, pupil behaviors, classroom grouping, educational material used, and subjects taught. The OScAR provides a method for analyzing and summarizing fourteen variables into three major categories called emotional climate, verbal emphasis, and social structure.

B. O. Smith and his associates (27) in a recent study 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. Strategies were viewed by Smith as sets of verbal behaviors employed as a means of achieving a content objective. The concepts of "venture" and "move," developed in previous research, are incorporated in the concepts of "verbal unit" and "strategy" to form a basis for identifying and clarifying the concept of "teaching strategy." Although Smith's study on teaching strategies deals primarily with cognitive aspects, there are other dimensions of the classroom situation considered. This study not only developed a system to describe and analyze classroom discourse associated with achieving content objectives, but it provided a means to conceptualize the verbal maneuvers involved in this aspect of the teacher's behavior.

Still another approach to the study of verbal behaviors in the classroom was reported by Muriel Wright (32). Wright's approach was unique since it was designed specifically for analyzing verbal behaviors in the secondary school mathematics classroom. Wright's system for classification of verbal behaviors was based on certain aims of mathematics teaching. The classification system consists of three frames of reference, each of 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.

The teacher-pupil interaction was classified in 12 high school algebra classes during observation periods of 45 minutes. The observer sat at a desk in the back of the classroom and used a stopwatch to determine the 15 second intervals. During each minute of observation two recordings were taken. In the four 15 second intervals in a minute, the first and third were used for observation, and the second and fourth for classification. The behaviors observed in the classroom were classified as positive or negative achievement of teacher or pupil in all three frames. Each of the 12 classrooms were visited four times. Wright found that differences in specific subject matter or age of pupils did not affect significantly the pattern of behaviors. This study also revealed information on the emphasis of categories in each of the frames. However, a more significant result of this study was that it provided a basis for general appraisal of the instrument developed by Wright which subsequently led to further study and modification.

Wright, in collaboration with Virginia Proctor (33), redefined and modified the categories of the instrument developed by Wright (31) for classifying verbal behaviors in the mathematics classroom. Wright and Proctor made assumptions much like those underlying Smith's (26) work, that is, they assumed that the teaching-learning situation must concentrate on the essential aspects of language. However, they projected their intentions beyond the logical aspects of language. They hypothesized that, while psychology gives the approach to problems, the complete solution is found in logic. In the revised instrument Wright and Proctor viewed the study of verbal behaviors from three viewpoints: mathematical content, psychological process, and sociological attitudes. A complete description of the instrument and a detailed discussion of the categories is given in Chapter III of this study.

The major study by Wright and Proctor involved the observation of 12 classrooms selected from 20 visited 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 experimental situation was achieved by selection rather than inducing the situation in the classroom. The verbal discussion of teacher and pupils in each of the 12 classrooms was studied using the Wright-Proctor instrument by one or both of the two experienced observers during 10 observation periods. The data collected were in terms of frequencies of behaviors in each category of the instrument.

The purpose of the study was to analyze the differences and similarities of the teacher-pupil interaction in the 12 classrooms observed. Basic to this study is the hypothesis developed by many experimental mathematics programs now being tried--the teaching of mathematics should be more systematic at all levels of instruction and the student should take an active part in the development as well as the application of important principles. Wright and Proctor found that an increase of participation, rigor constant, produced a greater emphasis of structure without lack of attention to technical skills. Likewise, an increase of rigor, participation constant, produced the same result. Another significant finding was that despite the reasonable concern of many teachers that marked student participation will limit unduly the amount of subject matter that may be presented, at the high school level the high participation group moved more rapidly than did the low participation group. Also revealed was that with low rigor and low participation classes there was an apparent routine which was supported by the observations taken in this type of class. The routine seemed to consist of the following sequence:

> Each class began with reading of answers to homework, followed by teacher explanation of difficulties; development of new materials by the teacher often with specific examples without supporting general proof or by statement of important relations without development, assignment of application, usually many of the same form with the teacher working one or two samples or with the limited student activity taking place here; sometime for supervised study for beginning homework problems. . . (33, p. 137)

Much more variety was observed in the high rigor, high participation classes which were found entirely in the university. It was also noted that the low rigor, high participation classes often would be modified from the patterns described above only by the students' joining in discussion of assignment difficulties or with pupils putting assignments on the board.

Summary

The developmental process of observation techniques and systems for classifying verbal behaviors in the teaching-learning situation has varied in approach, but there is a common research orientation. The instruments thus far developed reflect the investigators' philosophical, psychological, and/or sociological orientation. The techniques and specific approaches for measurement of classroom behaviors continue to be developed and redefined. It seems apparent that the psychological climate is the dimension that has been most thoroughly analyzed and successfully measured thus far.

The most significant aspect of the literature reviewed in this chapter is that behaviors of teachers as they teach and pupils while they learn are beginning to become objectively quantifiable through the use of relatively objective instruments.

CHAPTER III

INSTRUMENTATION OF THE STUDY

The purpose of this study was to attempt to identify characteristics of teacher-pupil interaction in the classroom setting, as measured by the *Wright-Proctor Observational Instrument* (33), that demonstrate a high degree of correlation with the average pupil gain scores, as measured by the arithmetic subtests of the *Stanford Achievement Test* (20). This purpose was fulfilled through the use of data gathered from the observation of teachers and pupils at the fifth-grade level and pupil gain scores determined from data secured from the research department of the Tulsa Public Schools.

The following description of the Wright-Proctor process for systematic observation of verbal interaction in the mathematics classroom will assist the reader in an understanding of this study.

Wright-Proctor Observational Instrument

The rationale for the development of this instrument was based on the fact that much of the research relating to the improvement of teaching has been dependent on indirect assessment of classroom variables. Medley and Mitzel (21) in a review of the developmental process of observational techniques point out that much of the research on teaching is limited to what goes on before and after whatever happens in the classroom. Although the indirect approach to research on teaching was recognized as valuable, Wright's (31) initial attempt was to develop an observational technique that would avoid certain of the variables encountered in the indirect approach. The previous several decades provided Wright with considerable support for the use of systematic observational techniques for direct assessment of verbal behaviors of teachers and pupils, but most of the previous studies had dealt with what Wright called "peripheral aspects" of the classroom. These peripheral aspects included such aspects as social climate.

Wright's (31) initial attempt in 1956 was to develop a multi-criterion approach to classify the language used in the mathematics classroom. In 1959 Wright (32) modified and refined the original instrument in an attempt to develop an instrument to study verbal behaviors in the secondary school mathematics classroom. The basic underlying assumption was that the key aspect of the classroom is the mastery of particular subject matter. Wright considered the subject matter taught and method of its development as the two important facts of a lesson. The categories for the instrument were developed from general educational objectives for the teaching of mathematics in the secondary school. Wright found that these objectives could be classified into three frames of reference: 1) ability to think, 2) appreciation of mathematics, and 3) curiosity and initiative. Wright selected and defined categories that could be used to classify particular types of behaviors under each of these broad frames. The several investigations made using this instrument were basically for establishing the validity of the categories or the observational techniques.

In 1961, Wright's instrument (33) was redefined and modified further in collaboration with Virginia Proctor. The instrument was modified so that the minimum number of categories necessary to sufficiently classify the language used by the teacher and pupils in thinking about mathematics was obtained. This concentration upon the essential aspects of language is not too dissimilar from the assumptions underlying Smith's (26) work. However, Wright and Proctor (33) projected their intentions beyond the logical properties of language. They hypothesized that, while psychology gives the approach to problems, the complete solution is found in logic. The essential aspects of language identifiable in the mathematics classroom were viewed in terms of three factors: content, process, and attitude. These essential aspects of language within the mathematics classroom were envisioned as being carried on through the vehicle of psychological processes and in the broad framework of sociological attitudes. Thus, the three frames of reference for classifying behaviors were established as mathematical content, psychological process, and sociological attitudes.

Mathematical Content Frame

Wright and Proctor (33) developed categories under the content frames which would answer the question, "What aspect of mathematics is being worked on?" The content frame was broken down into three broad facets of fundamentals, relations, and applications to facilitate the development of categories. The following categories were selected to correspond to aspects of mathematical systems and functional behaviors in the classroom: 1) fundamentals--structure, technique; 2) relations --deductive, inductive, statement; and 3) applications--mathematical, other.

Psychological Process Frame

Under the process frame categories were developed on the basis of logic. Wright and Proctor (33) emphasized that logic is the tool of mathematical thinking and as such provides the obvious basis for classifying verbal interaction in the mathematics classroom. The process frame was subdivided into the three levels of syllogistic, classificatory, and relevant. Categories were developed under each of these levels that would be expressive of certain types of behavior exhibited when building or applying a mathematical system using certain aspects of functional logic as a guideline. The following categories were developed under each level: 1) syllogistic--analyzing, synthesizing; 2) classificatory--specializing, generalizing; and 3) relevant--relevant.

Sociological Attitude Frame

In developing the categories for the attitude frame, Wright and Proctor were influenced by what Polya (21) suggested in describing the act of teaching mathematics as ensuring that each student does a "reasonable" share of the work. While the importance of both the passive and active behaviors in the mathematics classroom were recognized, they were particularly interested in the situation in which the role of the learner was moved from receptivity to independence. Wright and Proctor (33) designed the categories of the attitude frame to answer the question, "How much initiative are pupils asked to show, and how do they demonstrate?" The attitude frame consists of the categories of curiosity, independence, and receptivity.

Classification of Other Behaviors

In addition to the categories in the three frames described above, categories were developed to classify nonmathematical and nonverbal behaviors. The neutral category was defined to encompass any verbal behavior which was not concerned with mathematical matters. The four silent study categories were designed to classify different types of nonverbal behaviors in the classroom.

The Observation Process

The observation process consists of an observer observing the classroom interaction and classifying the types of verbal and nonverbal interaction. A single behavior is obtained by a time sampling which is determined by the use of a stop watch or a watch with a sweep second hand. Of the four 15-second intervals in each minute, the first and third are used for observation and the second and fourth are used for classification and recording. Thus, during each minute two observations are recorded. The behavior observed may be either a verbal or nonverbal behavior of the teacher or pupil. If the behavior observed is mathematical, it is classified under each of the three frames. A nonverbal nonmathematical behavior is classified as neutral, while a mathematical nonverbal behavior is classified as one of the categories under silent study.

A schema of classification of behaviors and the definition and description of the categories of the Wright-Proctor instrument is given in complete detail in Appendix A.

The Stanford Achievement Test

The data for the study were scores for the 215 fifth-grade students of the arithmetic subtest of the Stanford Achievement Test (20). The test scores were secured from the research department of the Tulsa Public Schools. The Stanford Achievement Test, Intermediate I Battery, Form X, was administered to the fourth-grade students in April of 1967 and the Intermediate II Battery, Form W, was administered to the same students as fifth graders during April of 1968. These scores were used to compute the average pupil gain for each of the eight classrooms on each of the three arithmetic subtests.

The Intermediate Battery of the Stanford Achievement Test (20) contains three arithmetic subtests: Arithmetic Computation, Arithmetic Concepts, and Arithmetic Applications. The Arithmetic Computation Test is designed to measure the proficiency in the computational skills in the fundamental operations of addition, subtraction, multiplication, and division. The Arithmetic Concepts Test is designed to test the understanding of basic mathematical concepts while the Arithmetic Application Test requires the student to apply his mathematical knowledge and ability to practical problems taken from life experiences.

Bryan (9) in a review of the Stanford Achievement Test (20) suggests that the intermediate battery reflects the contemporary changes in the mathematics curriculum particularity in the Arithmetic Concepts Test. Bryan feels that the 1964 revision of the Stanford Achievement Test (20) continues to be outstanding among tests of its kind in providing a measure of the mathematics curriculum known by the general term "arithmetic."

Summary

The instrument of analysis in this chapter comprised the instrumentation of this study. The Wright-Proctor Observational Instrument (33) was specifically designed to provide a technique for systematic observation of the verbal interaction in the mathematics classroom. The instrument provides a system for observing and coding the verbal interaction that takes place between the teacher and pupils. The behavior observed may be either a verbal or nonverbal behavior of the teacher or pupil.

The pupil gain scores were determined from data secured from the research department of the Tulsa Public Schools. These data consisted of the arithmetic subtest scores from the Stanford Achievement Test (20) for the 215 fifth-grade students which comprised the sample for this study.

CHAPTER IV

TREATMENT OF DATA

Selection of Subjects

This experiment took place within the school day during the academic school year. The investigation was conducted and data were gathered during the time ordinarily allotted to the regular arithmetic class period. The data consist of tallies made during the observation of 80 teaching periods of eight fifth-grade teachers in four elementary schools using the Wright-Proctor Observational Instrument (33). The rationale, purpose, and the content of this instrument were presented in Chapter III.

Selection of schools was on the basis of mean I.Q. scores and the number of teachers. 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 three fifth-grade teachers. The mean and medium I.Q. for the Tulsa elementary schools is 104. The elementary schools with the specialized arithmetic teachers were not considered in the selection of these schools even though they may have met the prescribed criteria. Likewise, schools that had grade five 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 central part 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. The schools were also selected fairly close together to facilitate the observation process by reducing the time involved in traveling from one school to another. The fifth-grade teachers and pupils in the four selected schools were the sample for this study.

Collection of Data

After the selection of the schools, a meeting was held in each school with the principal and the fifth-grade teachers explaining the study and asking for their cooperation. In this meeting it was explained that the teachers would receive a carbon copy of the coding sheet at the end of each observational period. The teachers were also 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.

Also obtained was the time each teacher normally taught arithmetic each day. This information was used to schedule two periods of familiarization and to further plan observation periods. Two familiarization periods were planned so that the teachers and students would 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.

Classes were not observed during a period which was being used as a testing session or immediately prior to or following a school holiday, all school activity, or school assembly. The classes were not observed when student teachers or substitute teachers were teaching. During the observational periods, the observer 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 grade five teachers instructing 215 grade five students in mathematics for 30 minute periods were transferred to a summary sheet.

Observer Reliability

The observer reliability data was gathered by having two observers independently observe the same arithmetic class. The observer, other than the writer, was conducting a similar study with fourth-grade classrooms in the same four schools. The observer reliability data included the recordings of simultaneous observation of each of the eight teachers by both observers. The concurrent observation periods were scheduled throughout the series of regular observation periods.

The observer reliability was tested in two different ways. Scott's index of inter-coder agreement (24) was calculated for each of the three frames of the instrument. Scott calls his coefficient "pi" and it is determined by the two formulae below (24, p. 322).

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

P_o is the proportion of agreement. P_e is the proportion of agreement expected by chance which is found by squaring the proportion of tallies in each category and then summing these over all categories.

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

In formula two there are k categories and p_i is the proportion of tallies falling into each category. Scott's coefficient, π, expressed in words is the amount that two observers exceed chance agreement divided by the amount that perfect agreement exceeds chance.

TABLE I

DETERMINATION OF THE LEVELS OF AGREEMENT BETWEEN OBSERVER 1 AND 2 USING SCOTT'S INDEX OF INTER-CODER AGREEMENT COEFFICIENT, π

Frame	π
Content	.91
Process	.88
Attitude	.95

Scott's index varies from 0.00 to 1.00, regardless of the number of categories and is unaffected by low frequencies. Wright and Proctor (33) recommend Flanders' adaption (14) of Scott's reliability coefficient as a useful method of reporting observer reliability. Wright and Proctor also suggest that observer reliability be tested by comparing the totals of the single categories across an entire frame. This comparison was made by applying chi square to the frequency totals of each category since Wright and Proctor established the independence of the single categories from each other. The following formula was used to calculate a chi-square value for each frame of the instrument (14, p. 228).

$$\chi^2 = \sum_{i=1}^{m} \frac{(0 - E)^2}{E} \qquad (3)$$

The number of degrees of freedom for this analysis is k(r-1) where k represents the number of columns (in this case 2), and r is the number of rows. Since the observers view the same number of behaviors during joint classification the columns are fixed and equal. The results of the chi-square comparisons are given in Table II.

TABLE II

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

Frame	Computed χ^2	df	Tabulated χ^{2*}
Content	4.8758	12	21.026
Process	3.0370	8	15.507
Attitude	0.1080	2	5.991

*Tabulated chi-square value at .05 level of confidence

The probability of a chi-square value greater than 4.8758, 3.0370, and 0.1080 observed is approximately .96, .92, and .94 respectively with the appropriate degrees of freedom. Thus, a hypothesis that the frequency totals for the observers were related would be accepted at the

.05 level of confidence since in each case the computed chi-square value is less than the tabulated value.

Significance of the Independent Variables

The results of the statistical tests of the hypotheses relating to the independent variables are presented below. The Spearman coefficient of correlation, r_s, was calculated for each independent variable using the rankings of total frequency of a given category over the ten observation periods for each teacher and the average pupil gain scores on each of the three arithmetic subtests of the Stanford Achievement Test (20). The first table reports the correlation between the total frequency of teacher behaviors classified as a given independent variable and the average pupil gain scores on each of the three arithmetic subtests. Likewise, the second table reports the correlation between the total frequency of pupil behaviors and each of the three arithmetic subtests. The third table in this series reports the correlation between the total frequency of the neutral and nonverbal categories with the average pupil gain scores on each of the three arithmetic subtests.

A Spearman coefficient of correlation of .643 is required for significance at the .05 level of confidence.

In the majority of the tests, the null hypothesis that no correlation existed between the independent and dependent variables was accepted. However, the results reported in Tables III and IV indicate that hypothesis 1a was rejected for the categories of synthesizing and independence. Likewise, hypothesis 2a was rejected for the category of technique. Hypothesis 3a was rejected for the categories of mathematical and receptivity while hypothesis 3b was rejected for the categories inductive and independence.

TABLE III

SPEARMAN COEFFICIENT OF CORRELATION BETWEEN RANKINGS OF THE AVERAGE PUPIL GAIN SCORES FOR THE EIGHT TEACHERS ON EACH OF THE THREE SUBTESTS AND THE TOTAL FREQUENCY OF TEACHER BEHAVIORS IN EACH CATEGORY

Category	Computation	Concepts	Applications
structure	.167	.263	-.163
technique	-.119	.691*	-.500
deductive	**	**	**
inductive	.560	-.107	.524
statement	.298	-.464	-.107
mathematical	.333	.119	-.714*
other	-.035	.196	-.059
analyzing	-.596	-.167	.024
synthesizing	.673*	-.313	.446
specializing	.429	.072	-.524
generalizing	.158	.059	.375
relevant	-.143	.619	-.428
curiosity	**	**	**
independence	.643*	-.071	-.167
receptivity	.238	.262	-.667*

*Significant at the .05 level of confidence

**Not enough data available to compute r_s

TABLE IV

SPEARMAN COEFFICIENT OF CORRELATION BETWEEN RANKINGS OF THE AVERAGE PUPIL GAIN SCORES FOR THE EIGHT TEACHERS ON THE THREE SUBTESTS AND THE TOTAL FREQUENCY OF PUPIL BEHAVIORS IN EACH CATEGORY

Category	Computation	Concepts	Applications
structure	-.214	.381	-.071
technique	-.190	.500	-.238
deductive	**	**	**
inductive	.284	-.473	.848*
statement	.420	-.330	.277
mathematical	0.000	.095	-.095
other	.170	.256	.527
analyzing	-.595	0.000	.119
synthesizing	.057	-.176	.473
specializing	.202	-.095	-.071
generalizing	-.295	-.164	.324
relevant	-.143	.072	-.286
curiosity	**	**	**
independence	.560	-.381	.643*
receptivity	.191	.095	-.095

*Significant at .05 level of confidence

**Not enough data available to compute r_s

TABLE V

SPEARMAN COEFFICIENT OF CORRELATION BETWEEN RANKINGS OF THE AVERAGE PUPIL GAIN SCORES FOR THE EIGHT TEACHERS ON THE THREE SUBTESTS AND THE TOTAL FREQUENCY OF BEHAVIORS OCCURRING IN THE NEUTRAL AND NONVERBAL CATEGORIES

Category	Computation	Concepts	Applications
neutral	-.119	.024	-.262
S1	.634	-.271	-.116
S2	-.500	.024	.548
S3	.464	.310	.072
S4	**	**	**

**Not enough data available to compute r_s

Theoretical Consideration

The significance of the results of this study merits some discussion in terms of implications for teaching elementary mathematics since one suggested purpose of this study was to learn more about the relationship of certain teacher and pupil behaviors and their effects upon mathematics achievement of pupils.

The teaching of arithmetic computation has long been recognized as an arduous task by many elementary school teachers. The findings that teacher behaviors classified as synthesizing and independence are positively correlated with arithmetic computation achievement provides some useful information that might be helpful in developing strategies for teaching arithmetic computation.

Since very little actual mathematical proof is done in the elementary school level, the behaviors classified as synthesizing generally referred to the consolidation of the parts of a problem into a whole or complete solution. The results suggest that many times children become so involved with the mechanical process of performing certain aspects of a mathematical operation that they overlook the importance of the complete process. This finding tends to reenforce the concept of the "whole" emphasized by Gestalt psychology. Also this result validates the logic of the basic premise of many of the modern mathematics programs that aims for understanding ahead of skills of operation.

Teacher behaviors classified as independence were found to be positively correlated to arithmetic computation achievement. This finding would add evidence that would tend to support Polya's (22) description of the art of teaching mathematics as insuring that each student does a "reasonable" share of the work.

In relation to the teaching of arithmetic concepts, the fact that teacher behaviors classified as technique were positively correlated with achievement in arithmetic concepts was rather surprising. Behaviors classified as technique were either behaviors referring to a mechanical process or rule where the basic mathematical relation is not made apparent or the reading of mathematical materials already developed such as answers to homework, assignment of homework, or just reading a problem from the text with no emphasis on specific conditions. It is understandable that the reading of answers to problems and homework would be valuable since it is important both mathematically and psychologically. However, the predominant use of the category technique which was the reading of mathematics from the textbook and the assignment of homework were common behaviors in all of the classrooms. Thus, this investigator had difficulty explaining this finding other than for chance.

Teacher behaviors classified as mathematical and receptivity were negatively correlated to achievement in arithmetic applications. The category of mathematical refers to the solution of mathematics problems. Thus, the frequency of occurrence of teacher behaviors classified as mathematical was higher in those classes where fundamentals and basic relations were not emphasized. It is interesting to note that this finding reenforces the basic assumption that underlies many of the modern mathematics programs, that is, the effective teacher of mathematics aims for understanding ahead of skills of operation. In other words, a teacher with a high frequency total of behaviors classified as mathematical in the content frame by necessity has a lower frequency of behaviors classified as structure, technique, and inductive. If the student did not have the basic understanding of the operations and properties involved, it follows that he would have difficulty in applying these same operations and properties to arithmetic application problems.

Teacher behaviors classified as receptivity were negatively correlated with achievement in arithmetic application problems which was not surprising considering that the category of curiosity was very seldom used. Thus, the only two possibilities in the attitude frame were independence or receptivity. This investigator was shocked that the total teacher and pupil behaviors for all eight classrooms classified as curiosity was only five. It is difficult to attribute this extremely small frequency to chance alone. It is very difficult to rationalize that with this small frequency of behaviors classified as curiosity that the teachers were encouraging creativity in the mathematics classroom.

The category of receptivity for teacher behaviors has reference to those behaviors in which the teacher tells, states, and solves problems; or when the teacher asks rhetorical questions which are limited to one step--often trivial or merely yes-no answers. A teacher that exhibits a high frequency of behaviors classified as receptivity is demanding very little participation of the student. Thus, the student is not challenged to analyze the problem and to apply his knowledge and understanding to the problem, but rather he merely follows the teacher's clue and responds to a question or watches as the teacher works the problem. Hence, it was not surprising that teacher behaviors classified as receptivity are negatively correlated to achievement in arithmetic applications problems.

The finding that pupil behaviors classified as independence and inductive were positively correlated with achievement on arithmetic applications problems again reenforces basic assumptions of many modern mathematics programs. Most of the modern mathematics programs have as a basic premise the goal of encouraging creativity by helping pupils discover the basic ideas and principles of mathematics. Since the power of mathematical proof is not generally available in the elementary school, the process of induction is the most powerful tool available to the student of mathematics on this level. It should be noted that the process of induction is basic to the process of "discovery" which many of the new programs emphasize.

The importance of helping each student to become more independent in his thinking and studying is receiving more and more attention in our schools. The finding that pupil behaviors classified as independence were positively correlated with achievement on application problems supports this emphasis at least in the field of mathematics. The category of independence refers to pupils' initiating discussions, asking questions, and making particular aspects of a problem or explanation clear.

During the course of the experiment the investigator noted an apparent class routine. This routine seemed to consist of the following sequence. Each class began with the development of new material or extension of previously developed material by the teacher. The teacher often asked the student to read and work orally the introductory material and examples in the textbook. Occasionally the teachers would ask pupils to work examples on the chalkboard. The teacher would then assign several similar problems to be worked in the remaining time in the arithmetic period. This time was used as a supervised study period with the teacher helping students with questions.

It was this investigator's observation that there was too much dependence on the textbook. Considerable class time was spent by having pupils read from the textbook. It is difficult for many pupils to visualize relations and to fully understand an explanation as it is being read aloud when dealing with abstractions. Thus, the student who is having difficulty in mathematics does not understand the explanation and consequently is lost when he attempts the assigned problems. However, many of the students could have read the introductory material themselves and worked the assigned problems with little trouble. Hence, it appeared that very little was being done to provide for the individual differences of the pupils. There was no ability grouping or variation of assignment with the classrooms observed. The basic fifth-grade textbook was the sole reference. The teachers steadily progressed through the text generally following the routine described above.

The over-dependence on the textbook might be partly explained by the insecurity of many elementary teachers about teaching modern mathematics. However, it is difficult to explain the apparent disregard for individual differences among learners.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was undertaken primarily to identify those characteristics of teacher-pupil interaction in the classroom setting as measured by the Wright-Proctor Observational Instrument (33) that demonstrate a significant correlation with average pupil gain scores in arithmetic. This purpose was fulfilled through the use of data gathered from the observation of teachers and pupils in four elementary schools. The eight fifth-grade teachers in these four schools were observed teaching 215 grade five students in mathematics periods of 30 minutes. The eight teachers were observed a total of ten times each.

The pupil gain scores were determined from data secured from the research department of the Tulsa Public Schools. The fourth- and fifth-grade test results of the Stanford Achievement Test (20) were used to determine the average student achievement gain for each teacher on each of the three arithmetic subtests.

The observer reliability data consisted of data collected from joint classification of observation periods of each of the eight teachers by two observers. The observer reliability was tested two different ways. The Scott coefficient of inter-coder agreement, π, was calculated for each frame of the instrument. The results yielded values of .91, .88, and .95 for the Content, Process, and Attitude frames respectively. The observer reliability was also tested by comparing the totals of the set of single categories across an entire frame using chi square. The chi-square value for each frame was not significant at the .05 level of confidence.

The significance of the independent variables was tested for both teacher behaviors and pupil behaviors since these are the basic components of the verbal interaction in the classroom. The Spearman rank correlation coefficient was calculated for the rankings of the average pupil gain scores for the eight fifth-grade teachers on each of the three arithmetic subtests of the Stanford Achievement Test (20) and the total frequency of teacher behaviors classified as a given category. Likewise, the Spearman rank correlation coefficient was calculated for the rankings of the average pupil gain scores for the eight fifth-grade teachers on each of the three arithmetic subtests of the Stanford Achievement Test (20) and the total frequency of pupil behaviors classified as a given category. The null hypotheses were that no correlation existed between the two sets of data under consideration in each case and that the observed value of r_s differed from zero only by chance. Significance was established at the .05 level of confidence.

Findings

On the basis of the statistical analysis the following findings can be stated:

1. Hypothesis 1a, that there is no significant correlation between fifth-grade average pupil gain scores on the arithmetic

computation subtest of the Stanford Achievement Test (20) and the total frequency of teacher behaviors classified as a given category was rejected for the categories of synthesizing and independence.

2. Hypothesis 1b, that there is no significant correlation between fifth-grade average pupil gain scores on the arithmetic computation subtest of the Stanford Achievement Test (20) and the total frequency of pupil behaviors classified as a given category was accepted for all categories.

3. Hypothesis 2a, that there is no significant correlation between fifth-grade average pupil gain scores on the arithmetic concepts subtest of the Stanford Achievement Test (20) and the total frequency of teacher behaviors classified as a given category was rejected for the category of technique.

4. Hypothesis 2b, that there is no significant correlation between fifth-grade average pupil gain scores on the arithmetic concepts subtest of the Stanford Achievement Test (20) and the total frequency of pupil behaviors classified as a given category was accepted for all categories.

5. Hypothesis 3a, that there is no significant correlation between fifth-grade average pupil gain scores on the arithmetic applications subtest of the Stanford Achievement Test (20) and the total frequency of teacher behaviors classified as a given category was rejected for the category of mathematical and receptivity.

6. Hypothesis 3b, that there is no significant correlation between fifth-grade average pupil gain scores on the arithmetic applications subtest of the Stanford Achievement Test (20) and the total frequency of pupil behaviors classified as a given category was rejected

for the categories of inductive and independence.

Conclusions of the Study

On the basis of this research and subject to the specified limitations, the findings of this study seemed to justify the following conclusions:

1. It was concluded that there is a positive correlation between teacher behaviors which exemplify the categories of synthesizing and independence and fifth-grade pupil achievement in arithmetic computation. This conclusion suggests that teachers should aim for understanding ahead of skills of operation in teaching arithmetic computation. It seems that children become so involved with the mechanical process of performing certain aspects of a mathematical operation that they overlook the importance of the complete process. Likewise, this conclusion also indicates that the teacher should ensure that each student does a reasonable share of the work.

2. It was concluded that there was no correlation between pupil behaviors classified as a given category of the Wright-Proctor instrument and pupil achievement in arithmetic computation.

3. It was concluded that there is a positive correlation between teacher behaviors classified as technique and fifth-grade pupil achievement in arithmetic concepts. This investigator had difficulty explaining the apparent relationship other than for chance.

4. It was concluded that there is no correlation between fifth-grade pupil achievement in arithmetic concepts and pupil behaviors classified as a given category of the Wright-Proctor instrument.

5. It was concluded that there is a negative correlation between teacher behaviors classified as mathematical and receptivity and fifth-grade achievement in arithmetic applications problems. This conclusion suggests that in classrooms where teachers spend considerable time in the solution of problems with little emphasis on the fundamental or basic mathematical relations involved the students tended to score lower on arithmetic applications problems. Also students tended to score lower on arithmetic application problems in those classrooms where the teacher told or stated the relation and solved problems with very limited student participation.

6. It was concluded that there is a positive correlation between pupil behaviors classified as inductive and independence and fifth-grade pupil achievement in arithmetic application problems. This conclusion indicates that it is important to help children discover basic ideas and principles of mathematics through induction. It also suggests that it is important for each student to become more independent in his thinking and expression of his ideas.

Recommendations

The investigator offers the following recommendations based on the conclusions of this study and in regard to further research.

1. It is recommended that programs of in-service education for elementary teachers in mathematics be developed. It is suggested that these programs not simply be efforts to update the teachers' vocabulary and mathematical knowledge, but also include the underlying philosophy of the modern mathematics programs and help the elementary teachers adapt the text and supplementary materials to the needs of their

students.

2. It is recommended that the Wright-Proctor instrument be used to further study the relationships of teacher-pupil interaction in the elementary mathematics classroom at varying grade levels.

3. It is recommended that the Wright-Proctor instrument be used to study classroom patterns in mathematics in various ability groups and in children from educationally deprived backgrounds. Furthermore, the instrument could be used to study various teaching techniques such as discovery teaching or to study certain aspects of teaching such as problem-solving episodes.

4. It is recommended that the Wright-Proctor instrument be used in pre-service or in-service method courses in mathematics teacher training programs to sharpen attention to certain aspects of the teaching act. The instrument could be used by the teacher or student teacher for self-evaluation and study while viewing a videotape or listening to a tape recording of the class presentation.

5. The Wright-Proctor instrument was designed for use in mathematics classrooms on the secondary school level. The categories of the instrument could be revised to make the instrument more adaptable to the less rigorous and less sophisticated mathematics in the elementary school.

6. It is recommended that the relationships between total staff attitudes toward pupil control and instructional strategies for teaching mathematics be investigated.

7. It is recommended that instructional strategies for teaching mathematics in pre-school and kindergarten classes be investigated.

The Wright-Proctor instrument may be directed to a variety of specific uses. The above recommendations for further study indicate a few specific areas that this investigator feels would be fruitful for future research. Studies of the type suggested above hopefully would produce more accurate information on the teaching-learning process in the mathematics classroom.

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APPENDIX A

THE WRIGHT-PROCTOR OBSERVATIONAL INSTRUMENT

<u>Definition of Categories</u>: 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?"

<u>Fundamentals</u>: 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

<u>Relations</u>: 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 focussing 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 Focussing 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 indication readiness to treat it themselves with teacher's assistance, e.g. How do you do this problem; I couldn't solve number 37

<u>Classification of Other Behaviors</u>: Neutral and Non-Verbal

<u>Neutral</u>

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.

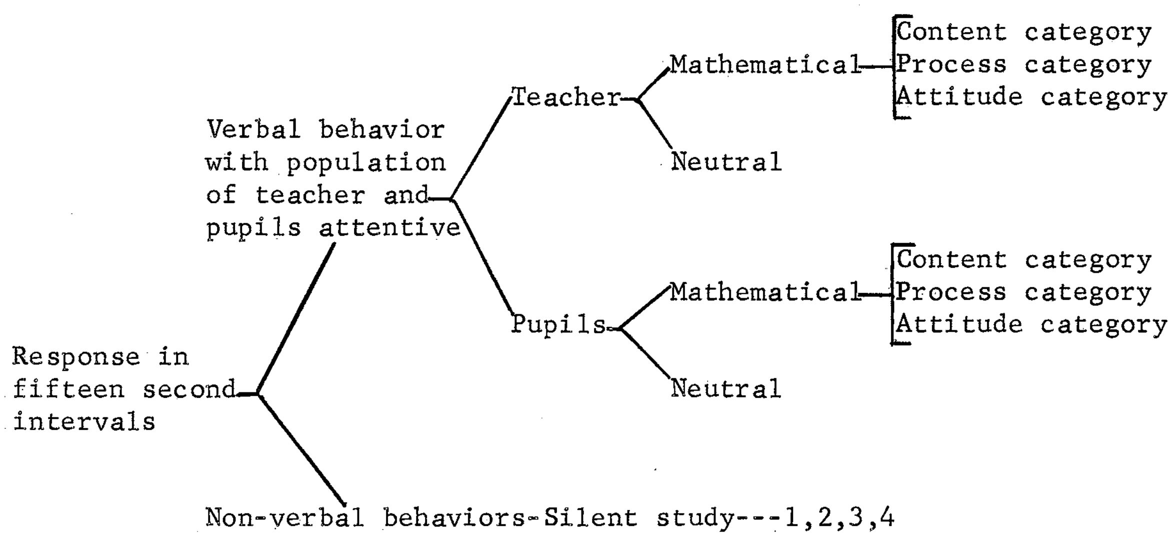
S1--Short periods of silence may comprise a complete interval set aside for classification of class interaction

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

Spearman Rank Correlation--Tied Ranks[1]

The following is the formula for the calculation of the Spearman coefficient of rank correlation, r_s, for the case where ties occur:

$$r_s = 1 - \frac{6\left(\sum_{i=1}^{n} d^2 + T' + U'\right)}{n^3 - n}$$

where $\sum_{i=1}^{n} d^2$ is the sum of the squared deviations

n is the number of ranks

$T' = \sum_t (t^3 - t)$ where t is the number of sets of ties in rank one

$U' = \sum_u (u^3 - u)$ where u is the number of sets of ties in rank two

[1]M. G. Kendall, Rank Correlation Methods, New York: Hafner Publishing Co., 3rd edition, 1962, p. 38.

VITA

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