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ABSTRACT

The study was designed to develop, test, and refine a model of teaching behavior for teachers of a first course in algebra. The model described five categories of teaching behavior which should be exhibited by algebra teachers. To aid in observation of these behavior categories, a modified Flanders interaction Analysis instrument was developed and is included in the report. The instrument was used to categorize verbal behavior of three ninth grade algebra classes each of ten teachers. A pretest of math ability and posttests of algebraic achievement and attitude toward the teacher were administered to the students in each of the ten classes. No significant differences were found between student achievement and attitude in relation to ratings of teachers on (1) years of teaching experience or (2) number of semester hours of credit in mathematics. However, teachers who had high correspondence to the model had higher student achievement and significantly (.05) higher student attitude toward the teacher than teachers having low correspondence to the model. (JG)

DEVELOPMENT OF A BEHAVIORAL MODEL FOR TEACHERS OF ALGEBRA[1]

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INTRODUCTION

This study was designed to develop, test, and refine a model of teaching behavior for teachers of a first course in algebra to ninth grade students. A general behavioral model was developed and was used to derive an initial specific behavioral model. Successive revisions of the initial specific behavioral model were made by including behavioral patterns which tended to be associated with higher student achievement and/or better student attitude towards the teacher and excluding behavioral patterns which tended to be associated with lower values of these variables. The culmination of these revisions was the final specific behavioral model which is presented as the major result of this study.

A more complete report of this study includes the following: (1) the ranges of behaviors exhibited for each teacher considered in this study, (2) the initial, intermediate, and final specific behavioral models, (3) reliability, coding, and data-processing procedures, and (4) the major computer program which was designed to process the data of this study. (1)

REVIEW OF RELATED LITERATURE

Hilgard (2) emphasized the agreement of learning theorists of all schools that learning is most effective for the learner who is actively involved in the learning process and operating under the motivation of positive reinforcement.

Schuner, (3), Leonhardt (4), and Sparks (5) as well as others have

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found various relationships between school-related factors and student achievement in mathematics. In general, school-related factors have tended to be sufficiently confounded with each other and with teacher-related factors that they have not served as effective predictors of student achievement. Furthermore, teacher characteristics such as academic background and experience have not served as effective predictors of student achievement. Nevertheless, such investigators as Larsen (6) and Dunn (7) concluded that the teacher factor was the overriding consideration in determination of student achievement.

Flanders (8), Amidon (9), and many others have concluded that a highly important aspect of teacher influence on student outcomes is the in-class verbal behavior of the teacher.

More recent studies with which this author has been closely associated have studied teacher behavior in finer detail than was done in earlier studies, (10,11,12,13,14). These studies have focused on the sequential nature of classroom interaction as well as discrimination of various subcategories of verbal behavior within the broad categories developed by Flanders.

Mathematics educators such as Butler and Wren (15) and Johnson and Rising (16) also emphasize a high level of student involvement in the mathematics classroom. This is to be accomplished through skillful questioning techniques on the part of the teacher.

PROCEDURE

On the basis of the review of the literature, knowledge of ongoing research in teacher behavior, the advice of colleagues, and the experience of the author a general behavioral model was developed. In broad terms this model stated that the teacher of ninth grade algebra should: (1) be indirect and flexible in the use of his teaching influence, (2) frequently

employ techniques designed to encourage student discovery of mathematical procedures and principles, (3) emphasize the structure of the mathematical system being studied, (4) obtain a high level of student participation in his classes, and (5) carefully plan and evaluate his lessons.

Many of the implications of the broad statements were related to behaviors which were amenable to direct observation in the classroom. These observable behaviors became the basis for a variety of "behavioral keys" which were developed and were used as indices of the extent to which a teacher employed a given type of behavior.

A modified Flanders Interaction Analysis instrument was developed for purposes of this study and is displayed in Table I. This instrument was designed specifically for use in mathematics classrooms and contains several features which would not be relevant to classrooms in other content areas.

An initial specific behavioral model was developed in terms of recommended ranges of extent of occurrence of a number of events which were objectively observable by means of the observation instrument developed for this study. Those items which were retained in the final specific behavioral model will be found in Table II.

The author trained a second observer to high reliability with himself (Scott reliabilities of 90% for major categories and 80% for subcategories). Each of the ten teachers observed in this study were observed three times in each of two classes. A tape recording of each class session was made to permit checking of the data.

All teachers involved in this study taught in the same large school system. All taught at least two sections of ninth-grade algebra in traditionally scheduled junior high schools with fifty-five minute periods. All classes completed approximately the same number of pages in the same textbook (Dolciani, Berman, and Freilich. Modern Algebra Structure and Method, Book 1).

TABLE I

MODIFIED INTERACTION ANALYSIS INSTRUMENT USED IN THIS STUDY

MAJOR CATEGORY	SUB-CATEGORY SYMBOL	INTERPRETATION
1		Accepts student feelings
	1	Accepts student feelings
2		Praises or encourages
	2	Positive reinforcement of student response
	2a	Verbal habit positive reinforcement
	2g	General encouragement of individual or class
	2h	Use of humor
3		Accepts or uses ideas of students
	3	Acceptance and development of student idea
	3e	Request for student to explain or expand his previous statement
	3q	Referral of student statement to class, especially as a question
	3r	Repetition of student statement
4		Asks questions
	4	General questions
	4a	Question of factual nature with limited response set-specific answer desired
	4d	Question of a developmental or discovery nature with broad response set
	4p	Request for proof or reason for statement
	4q	Request for student questions
5		Lecturing
	5	General lecture
	5e	Examples
	5p	Proof or reasons for statements
	5x	Explanation at the request of a student
6		Giving directions
	6	Directions to individual or class
	6a	Assignment
	6s	Student required by teacher to respond
7		Criticizing or justifying authority
	7	Criticism of individual or class
	7n	Indication of incorrect answer
	7d	Criticism of disciplinary nature
	7t	Defense of self or procedure

MAJOR CATEGORY	SUB-CATEGORY SYMBOL	INTERPRETATION
8		Student talk - response
	8	General student talk initiated by teacher
	8n	Indication of lack of knowledge or unwillingness to respond
	8b	Student at board explaining his work of a mechanical nature
	8bp	Student at board giving proof or reasons for statements
	8p	Student giving proof or reason for statements
	8q	Student question in response to teacher question
9		Student talk - initiation
	9	General student initiated talk
	9b	Student at board explaining his work of a mechanical nature
	9bp	Student at board giving proof or reasons for statements
	9q	Student initiated question not in response to teacher question
10		Silence or confusion
	10	Silence or confusion
	10b	Student(s) working at board and not explaining work to class
	10m	Mechanical adjustments
	10s	Student seatwork
Special Symbols		
	/	Used to indicate a change in student speaker without intervening teacher talk
	//	Used to indicate a change in the nature of classroom activity
	—	Gatekeeping by teacher - indicates who is to speak among volunteers

Student prior mathematical achievement was measured by scores on the California Arithmetic Battery, Form Y. For all students considered in this study this measure was obtained in the Spring prior to the Fall in which they were enrolled in the algebra course. Student achievement in algebra was measured by the score obtained on the Lankton First-Year Algebra Test, Revised Edition which was administered at the end of the first semester of algebra. Student attitude towards the teacher was measured by the Nebraska Student Attitude Scale at the end of the first semester.

FINDINGS

The mean within class correlation of prior mathematical achievement and algebra achievement was 0.593. However, when the correlation was computed across teachers using class averages, it was found to be only 0.139. Thus, within given classes students with higher prior achievement may be expected to obtain higher algebra achievement, but the average prior achievement score of a class had little predictive value across teachers. Thus, analysis of covariance was not used to adjust algebra achievement for differences in prior achievement. The great difference in the relationship between these two variables when considered from the two points of view was taken by this author as an indication of the potency of the effect of the teacher on student achievement.

When testing results were compared by teacher, it was found that neither student achievement nor student attitude were significantly different among teachers who rated high and those who rated low on the following variables: (1) years of teaching experience, (2) number of semester hours of credit earned in mathematics, and (3) correspondence to the initial specific behavioral model.

Four revised specific behavioral models were developed. The first two revisions were called the achievement model and the attitude model

respectively. The recommended ranges for the keys in these two models were established so as to maximize the difference in the average value of the criterion variables between the set of teachers who corresponded to the model and those who did not correspond to the model for each key. In each case the set of teachers who had "high" correspondence to model scores had significantly higher criterion scores than did teachers who corresponded to the model at a "low" level.

The third of the revised specific behavioral models was called the set intersection model because the recommended ranges for behavioral keys in this model were formed by taking the intersection of the ranges suggested by the attitude model and the achievement model. This model partitioned the teachers so that the set having "high" correspondence to the model had higher student achievement and significantly higher student attitude toward the teacher than did teachers having "low" correspondence to the model.

The development of the three revised specific behavioral models was undertaken, in part, as an exercise in the empirical development of behavioral models. Since the recommended ranges were selected solely on the basis of the data of this study, previous behavioral research was not considered. The information gained in this manner was valuable in the development of the final specific behavioral model, but thsse intermediate models had to be considered in light of the arbitrary nature of the process used to develop them.

The recommended ranges for the behavioral keys for the final revised specific behavioral model were determined on the basis of the previous research cited, the data of this study, and the author's experiences with the teachers in this study. The description of the behavioral keys retained in this model as well as their recommended ranges may be found in Table II.

TABLE II

FINAL SPECIFIC BEHAVIORAL MODEL

Key No.	Symbol	Model Range	Interpretation of Behavioral Key
1	RI/I+D T	0.620 to 0.700	Proportion of tallies in categories 1,2,3,6, and 7 which are in categories 1, 2, or 3 for total period
2	I/I+D T	At least 0.333	Proportion of all teacher talk tallies which are in categories 1, 2, 3, or 4 for total period
3	6-7 CELL	At most 0.020	Proportion of all tallies corresponding to extended giving of directions (except for giving assignments) or criticism
4	2A/2	At most 0.300	Proportion of all reinforcement tallied as a verbal habit
5	TOT 2H	At least 0.005	Proportion of all tallies corresponding to teacher use of humor
6	TOT 7D	At most 0.005	Proportion of all tallies corresponding to teacher use of discipline
7	TOT 10SC	At most 0.045	Proportion of all tallies corresponding to silence or confusion
8	BOARD WK	At least 0.050	Proportion of all tallies corresponding to student board work
9	SEAT WK	0.100 to 0.250	Proportion of period spent in student seat work
10	SEQ MIN	At least 0.050	Minimum proportion of all sequences in each of the subclasses I-8, D-8, D-9, or I-9
11	SEQ MAX	At most 0.250	Proportion of all sequences represented by most frequently occuring sequence family
12	RI/I+D	0.720 to 0.800	Proportion of all tallies in categories 1, 2, 3, 6, and 7 which are in categories 1, 2, or 3 during discussion

TABLE II

FINAL SPECIFIC BEHAVIORAL MODEL

Key No.	Symbol	Model Range	Interpretation of Behavioral Key
13	I/I+D	At least 0.400	Proportion of all teacher talk tallies which are in categories 1, 2, 3, or 4 during discussion
14	RI/I+DFS	0.850 to 0.960	Proportion of all teacher talk in categories 1, 2, 3, 6, or 7 following student talk which falls into categories 1, 2, or 3 during discussion
15	I/I+DFS	0.700 to 0.875	Proportion of all teacher talk following student talk which falls into categories 1, 2, 3, or 4 during discussion
16	I/I+DLS	0.700 to 0.875	Proportion of all teacher talk leading to student talk which falls into categories 1, 2, 3, or 4 during discussion
17	TOT 8+9	At least 0.250	Proportion of all tallies which correspond to student talk during discussion
18	TOT 4	At least 0.120	Proportion of all tallies which correspond to teacher questions during discussion
19	TOT 3	At least 0.100	Proportion of all tallies which correspond to building on student ideas during discussion
20	TOT 1	At least 0.005	Proportion of all tallies which correspond to acceptance of student emotion during discussion
21	TOT 5	At most 0.0450	Proportion of all tallies in the major category lecture
22	4P/4	At least 0.050	Proportion of all teacher questions which involve asking for proof of some statement during discussion
23	4D/4	At least 0.050	Proportion of all teacher questions which are of the developmental or discovery nature during discussion

TABLE II

FINAL SPECIFIC BEHAVIORAL MODEL

No.	Key Symbol	Model Range	Interpretation of Behavioral Key
24	4-8/TOT8	At most 0.500	Proportion of teacher initiated student talk which occurred within three seconds after a teacher question during discussion
25	5E/TOT5	0.200 to 0.400	Proportion of all teacher lecture which consists of giving examples during discussion
26	8Q+9Q/89	0.090 to 0.200	Proportion of all student talk which consists of the student's asking the teacher a question during discussion
27	8-8/TOT8	0.200 to 0.400	Proportion of all teacher initiated student talk which occurred more than three seconds after the conclusion of teacher talk during discussion
28	9-9/TOT9	0.250 to 0.400	Proportion of all student initiated student talk which occurred more than three seconds after the conclusion of teacher talk during discussion
29	EXT 8	At least 5 per period	Number of episodes of teacher initiated student talk of duration twelve seconds or more during discussion
30	NO. s/s	At least 5 per period	Number of student to student interactions during discussion
31	123 CELL	At least 0.045	Proportion of tallies corresponding to extended use of categories 1, 2, and 3 during discussion
32	8Q5X/8QT	At least 0.500	Proportion of student questions in response to teacher questions which are followed by teacher explanation during discussion
33	8N/TOT8	At most 0.010	Proportion of student answers which consist of lack of knowledge or unwillingness to respond during discussion

TABLE II

FINAL SPECIFIC BEHAVIORAL MODEL

Key No.	Symbol	Model Range	Interpretation of Behavioral Key
34	4-8Q/4-8	At most 0.040	Proportion of student responses to teacher questions which are questions during discussion
35	46s4/48s	At least 0.100	Proportion of teacher questions which are associated with teacher direction of whom is to answer during discussion

CONCLUSIONS

On the basis of the data of this study and the author's experiences with the teachers in this study, the following conclusions were reached:

1. Previous research which indicated that the teacher has a significant influence on the level of student achievement was supported.
2. Previous research which indicated that such teacher factors as experience and academic background have uncertain effects on student achievement was supported.
3. Previous research which indicated that teachers who are indirect, use student ideas more than an average amount, lecture less than an average amount, have more student talk than average, and have better student achievement and better student attitude toward teachers was supported.
4. Although the "modern mathematics" approach claims to emphasize discovery, teaching of structure, and proof in the algebra class, behaviors related to these emphases were observed only very infrequently in this study.
5. The final revised specific behavioral model is appropriate for emulation by pre-service and in-service teachers of mathematics. Persons involved in the education of mathematics teachers should have as one of the objectives of their program the training of teachers to be able to effectively control the extent to which they exhibit each of the behaviors discussed in this study. The student should be trained to analyze his own behaviors and to compare them to the model.

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