DOCUMENT RESUME

ED 087 697 SP 006 592

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TITLE Teacher Styles in Questioning and Explaining. Technical Report No. 39.
INSTITUTION Stanford Univ., Calif. Stanford Center for Research and Development in Teaching.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
REPORT NO TR-39
PUB DATE Oct 73
CONTRACT NE-C-00-3-0061
NOTE 41p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS Analysis of Variance; Cognitive Ability; Individual Differences; *Questioning Techniques; Sex Differences; *Teacher Characteristics; Teaching Experience; *Teaching Styles; *Teaching Techniques

ABSTRACT

The primary purpose of this study was to identify and describe individual differences in teaching style (i.e., teachers' patterns of questioning and explaining) in a standardized teaching situation. The secondary purpose was to explore relationships between teaching behavior and other teacher characteristics: teaching experience; sex and selected cognitive abilities (verbal, reasoning, and spatial); and cognitive style (field independence). To standardize teaching conditions, a teaching "game" that simulated a dyadic teacher-student instructional situation was developed. The game had student, teacher, and curriculum components. Twenty experienced teachers (10 men and 10 women) and 12 individuals with no teaching experience (6 men and 6 women) participated. Each taught one "student" from each of four types classified on the basis of knowledge of subject matter (high or low) and learning ability (fast or slow). Analyses of variance showed significant differences in teaching behavior related to the student characteristics and to two teacher characteristics (teaching experience and sex). Inexperienced teachers emphasized statement of rules more than experienced teachers did. Women emphasized relationships underlying rules more than men did. Correlational analysis showed significant relationships between teaching behavior and teaching experience, sex, age, verbal ability, and field independence. (Author/DDO)

STANFORD CENTER
FOR RESEARCH AND DEVELOPMENT
IN TEACHING

Technical Report No. 39

TEACHER STYLES IN QUESTIONING AND EXPLAINING

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October 1973

Published by the Stanford Center for Research and Development in Teaching, supported in part as a research and development center by funds from the National Institute of Education, U. S. Department of Health, Education, and Welfare. The opinions expressed in this publication do not necessarily reflect the position, policy, or endorsement of the National Institute of Education. (Contract No. NE-C-00-3-0061.)

Introductory Statement

The Center's mission is to improve teaching in American schools. Too many teachers still employ a didactic style aimed at filling passive students with facts. The teacher's environment often prevents him from changing his style, and may indeed drive him out of the profession. And the children of the poor typically suffer from the worst teaching.

The Center uses the resources of the behavioral sciences in pursuing its objectives. Drawing primarily upon psychology and sociology, but also upon other behavioral science disciplines, the Center has formulated programs of research, development, demonstration, and dissemination in three areas. Program 1, Teaching Effectiveness, is now developing a Model Teacher Training System that can be used to train both beginning and experienced teachers in effective teaching skills. Program 2, The Environment for Teaching, is developing models of school organization and ways of evaluating teachers that will encourage teachers to become more professional and more committed. Program 3, Teaching Students from Low-Income Areas, is developing materials and procedures for motivating both students and teachers in low-income schools.

The study reported here was conducted as a part of the Program on Teaching Effectiveness.

Contents

TEACHER STYLES IN QUESTIONING AND EXPLAINING[1]

Carol Ann Moore

Individual differences in teaching style have frequently been observed by educational researchers and teacher trainers (Wallen & Travers, 1963; Goldberg, 1964; Taba, 1966). For example, Taba (1966) reported the following about teachers she trained to use a particular set of teaching techniques:

> An interesting phenomenon was the great variation among teachers and classrooms [p. 224].
>
> The present study left no doubt that certain teacher behaviors can be modified in ten days of training. However, it was equally clear that not all teachers modified their teaching behaviors in the same amount. Neither did any become perfect representatives of the open-ended style of teaching required for development of autonomous use of cognitive skills [by elementary school children], because variables other than those affected by training in strategies remained in effect [p. 225].

While "teaching methods" propose ideal patterns of teaching behavior (Wallen & Travers, 1963; Joyce & Weil, 1972), at each step in the teaching process the teacher has to make new decisions about what to say or do next to attain the objectives of the teaching session (McDonald, 1965; Taba, 1966; Snow, 1969; Shavelson, 1972). These decisions may be influenced in part by training in teaching methods, but they may also be influenced by situational factors and by the personal characteristics of

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[1]Presented at the Annual Meeting of the American Educational Research Association, New Orleans, February 1973. The author was a Research Assistant at the Center when this study was conducted. She is now a USPHS postdoctoral fellow at the Educational Testing Service.

the teacher. If individuals are at all consistent in how they make on-the-spot teaching decisions, whether they make them consciously or intuitively, they should show consistent patterns of teaching behavior. Until individual patterns of teaching behavior or teaching styles can be described, the implications of individual differences for teacher training or for teacher effectiveness with different types of students cannot be adequately assessed.

The primary purpose of this study was to identify and describe individual differences in teaching style associated with two aspects of teaching--questioning and explaining. Teachers' sequencing of certain types of questions and statements were accepted as symptoms of decisions made in structuring verbal information for the learner and in soliciting and using feedback from the learner. A second purpose was to explore relationships between teaching behavior and the other teacher characteristics. Teacher characteristics, selected to provide a wide range of information, were previous experience (amount of teaching experience), sex, intellectual or cognitive abilities (verbal, reasoning, and spatial) and cognitive style (field independence). Since this was an exploratory study, no specific hypotheses were offered predicting the nature of different teaching styles or the effects of different teacher characteristics on teaching behavior.

Method

Simulation of Teaching Conditions

At a very minimum, teacher decisions and teacher-student interaction are regulated by the curriculum content and structure, by

immediate instructional goals, by the student's learning capacities and knowledge, by the capabilities and style of the teacher, and by the particular setting (Taba, 1966; Snow, 1969; Moore, 1973). A major problem in gaining descriptive information on teaching styles lies in controlling enough classroom-teacher-learner dimensions to allow comparisons across teachers. Each classroom and each teaching situation is different. One way of standardizing teaching conditions is to use laboratory microteaching conditions, in which a teacher instructs only five or six students on specified topics for a set amount of time (Berliner, 1969; Snow, 1969). Another is to attempt to simulate teaching conditions without enlisting students (Tansey, 1970; Taylor, 1972).

In this study, a "teaching game" was developed to simulate a dyadic teacher-student instructional situation. The game forms a system with student, teacher, and curriculum components (see Figure 1). The

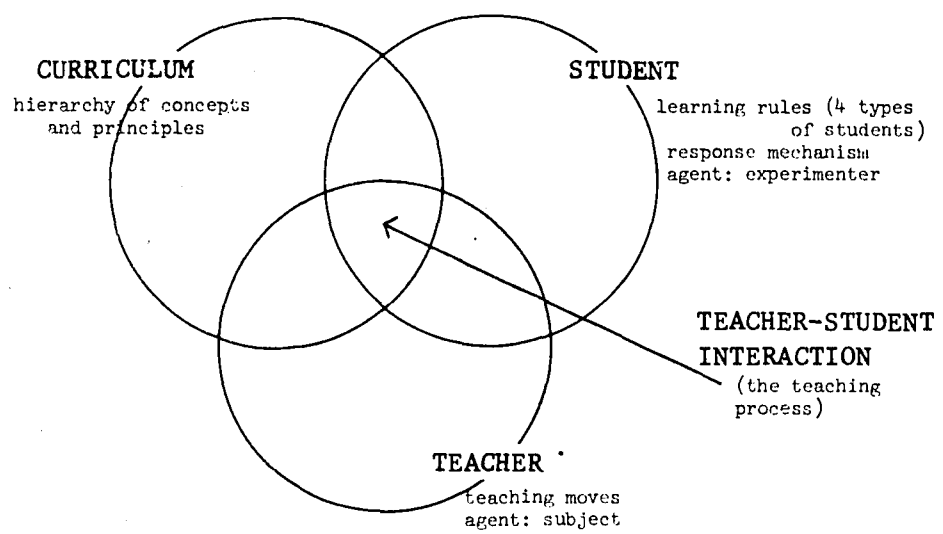
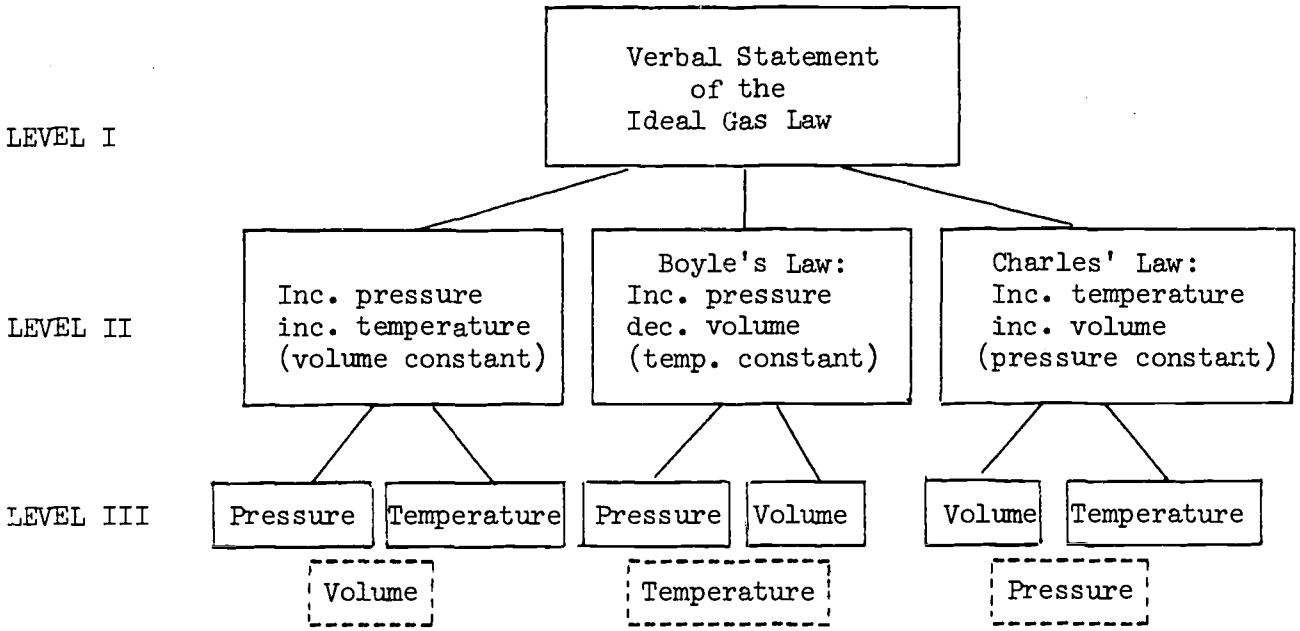


Figure 1. Teaching game components.

curriculum component consists of hierarchically arranged concepts and principles, in this case the chemistry pressure-temperature-volume gas laws (Gagné, 1970), which the student should be able to state and explain at the end of a teaching session (see Figure 2). The student component consists of a means for student communication with the teacher and a set of rules explicitly governing student learning, which is contingent on teacher behavior. The teacher component consists of a repertoire of verbal phrases related to the curriculum. Two agents are necessary in the game: a teacher, and a person (or, when available, a computer) to follow the student learning rules and provide feedback to the teacher on student learning. In this study, each subject acted as "teacher," while the experimenter supervised "student" learning.

In the game, each "teacher" is given the task of teaching the gas laws to each of six students. The teacher must determine when the educational objectives for the session have been reached, i.e., when the student can state and explain the gas laws, including the equations representing the laws. To teach a student, the teacher chooses among 86 possible "teaching moves." A "move" is either a question or a statement pertaining to the gas laws and gas behavior (see Tables 1 and 2). The "student" is simulated by a set of learning rules (see Table 3) and communicates with the teacher through a pair of lights (a "correct" light and an "incorrect" light). When the teacher asks a question, the lights indicate whether or not the student can answer the question correctly. Each student has individual learning characteristics that determine his response to any question asked by the teacher. Students' knowledge of the subject matter and their learning ability are

VERBAL FORM



ALGEBRAIC FORM

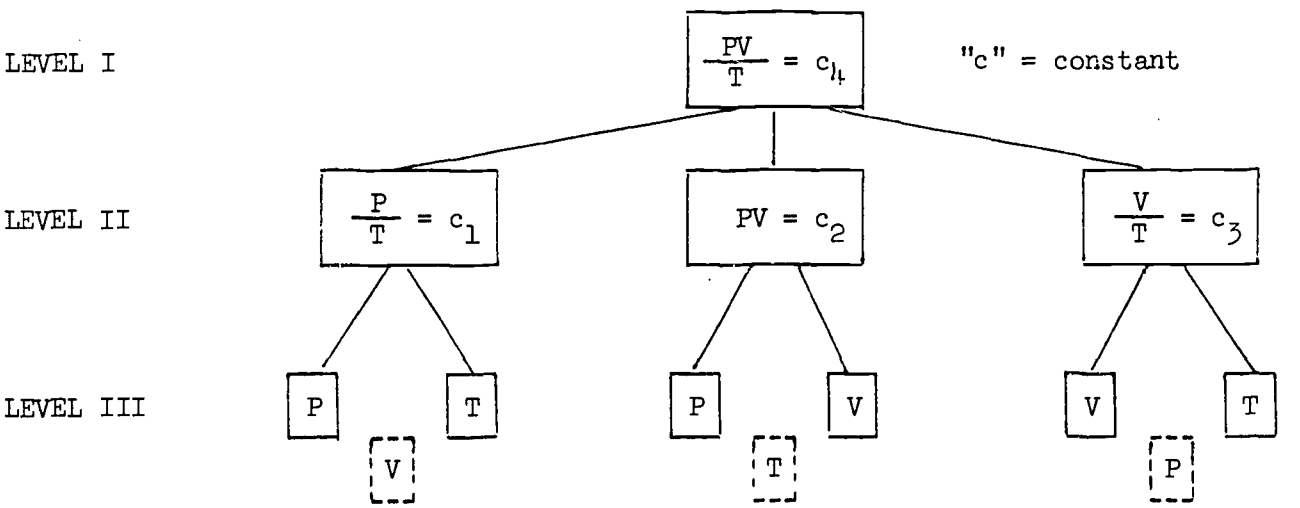


Figure 2. Learning hierarchy for the gas laws.

TABLE 1

Types of Moves

Level	Verbal Statement	Algebraic Form
I. Ideal Gas Law	Formal statement	Equation
	Informal statement	
	Relationship	Relationship
	2 Everyday examples	
	Lower-order question	Lower-order question
	Higher-order question	
	Higher-order question[a]	
II. Component Gas Laws (for each law)	Formal statement	Equation
	Informal statement	
	Relationship	Relationship
	3 Everyday examples	
	Lower-order question	Lower-order question
	3 Higher-order questions	
III. Concepts (for each concept)	Formal definition	Symbol
	Informal definition[b]	
	3 Everyday examples	
	Lower-order question	Lower-order question
	3 Higher-order questions	

[a] In addition, there were three higher-order questions which related the component gas laws to the Ideal Gas Law.

[b] There was no informal definition for "volume." An additional statement about volume was included instead.

TABLE 2

Examples of Teaching Moves

Moves Relating to the Concept of "Pressure":	
Informal definition	"The push of a gas against the walls of a container is the 'pressure'."
Example	"If you puff out your cheeks, you can feel the pressure inside your cheeks."
Lower-order question	"What does the letter 'P' represent?"
Moves Relating to the Pressure-Temperature Rule:	
Formal statement	"The pressure-temperature rule states that change in pressure of a given amount of gas is directly proportional to change in temperature at constant volume."
Relationship	"The pressure of a gas decreases when the temperature is decreased, if the volume remains constant."
Higher-order question	"Why is the pressure in your car tires greater after driving an hour than it was when you started?"
Moves Relating to the Ideal Gas Law:	
Informal statement	"The Ideal Gas Law says that if the pressure of a gas has increased, the volume may have decreased, the temperature may have increased, or both."
Equation	"The Ideal Gas Law is described by the Ideal Gas Equation: $\frac{PV}{T} = c$, where 'c' is a constant."
Algebraic relationship	"If V decreases or T increases, P increases."
Moves Integrating the Ideal Gas Law and the Component Gas Laws:	
Higher-order question	"In what ways could the pressure of a gas be increased by changing other gas conditions?"

TABLE 3

Examples of General Rules for Student Learning

Fast Learners	Slow Learners
Learning Rules for Concepts:	
If the student is given two examples, he learns and understands the concept.	If the student is given the definition and an example, he learns and understands the concept.
Learning Rules for Component Rules Describing Relationships Among Gas Conditions:	
If the student is given a rule when he knows the component concepts, he learns and understands the rule.	If the student is given a rule, plus the relationship underlying the rule when he knows the component concepts, he learns the rule, but he can not apply it.
If the student is given two examples, plus the relationship exemplified when he knows the component concepts, he learns and understands the rule.	If the student is given an example of the rule when he has learned the rule, he understands the rule and can apply it.
Learning Rules for the Ideal Gas Law:	
If the student is given the full gas law when he knows the component concepts, he learns and understands the full gas law.	If the student is given the full gas law when he knows the component concepts and at least one component rule, plus he is given the relationship underlying the rule, he learns the full gas law, but he can not apply it.
Learning Rules for Integrating Component Rules and the Ideal Gas Law:	
If the student knows Boyle's Law and the pressure-temperature rule, he can compare the two.	If the student knows the full gas law, Boyle's Law and the pressure-temperature rule, he can compare the two component rules.

systematically varied, yielding four types of student: high knowledge, fast learners (HF); low knowledge, fast learners (LF); high knowledge, slow learners (HS); and low knowledge, slow learners (LS).

Subjects

The subjects were twenty teachers (10 men and 10 women) with classroom teaching experience and 12 individuals with no teaching experience (six men and six women). They were paid volunteers recruited by leaflets distributed around a university and the neighboring communities. The subjects ranged in age from 17 to 36 years, in education from high school to doctoral degrees, in occupation from self-employed to student to professor, and in teaching experience from none to 10 years.

Design

The experiment was designed to test the effects of teaching experience, the sex of the teacher, and student characteristics on teaching behavior in the game. Each subject taught the same four "students" in the teaching game, one of each type: HF, LF, HS, LS. The design, a four-factor experimental design with repeated measures on the two student factors, is portrayed in Figure 3.

Before the game session, each subject took four cognitive tests, filled out a general information questionnaire, and passed the achievement test covering the gas laws. In addition, each subject was interviewed after the game. Each of these measures is described below.

Measures

Questionnaire. The questionnaire asked for general information about the subjects, including age, profession, teaching experience, and educational preparation.

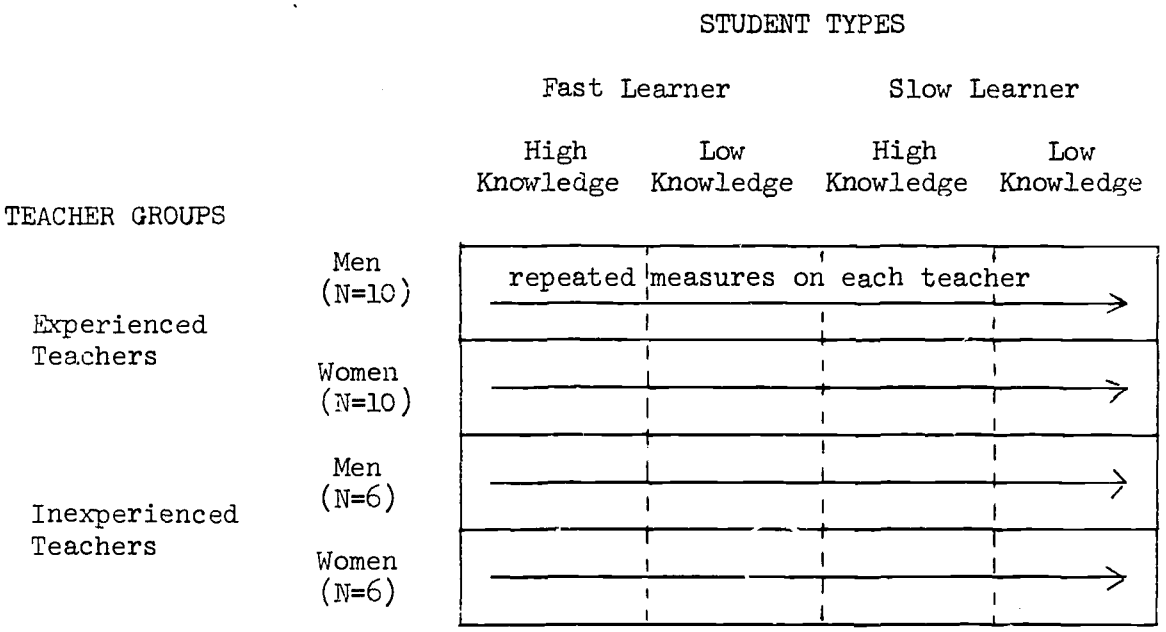


Figure 3. Experimental design: Four-factor (Teaching experience x Sex x Student learning ability x Student knowledge) with repeated measures on the student factors. (The students were taught in random order with all 24 possible sequences represented across subjects. Before teaching these students, each subject taught two additional students for practice: a high knowledge, fast learner and a low knowledge, slow learner.)

Achievement test. The achievement test measured knowledge of the pressure-temperature-volume gas laws at the level of simple problem solving using the appropriate equations. Eight of the questions were multiple-choice and two were essay. Criterion performance on the test (80 percent correct) indicated mastery of the subject matter beyond the requirements of the game curriculum. Since the test was used only to ensure that subjects knew the subject matter involved in the game, reliability and validity checks were not made.

Cognitive tests. Four cognitive tests (French et al., 1963) were administered. These tests measured verbal ability (Extended Range Vocabulary Test, Parts I and II), reasoning ability (Necessary Arithmetic Operations, Parts I and II), spatial ability (Form Board Test, Parts I and II), and field independence (Hidden Figures Test, Parts I and II).

Interview. In the interview after the game, three questions were usually asked by the experimenter during the conversation: "How do you think your teaching in the game is similar to and different from your teaching in a classroom?," "What differences did you perceive among your students in the game?," and "What comments can you make about the game in general?" The first question was modified for inexperienced teachers to "how you might teach." Of the 32 interviews, 30 were tape recorded and transcribed.

Procedures

Testing session. Before playing the game, subjects met with the experimenter or a research assistant for a 90-minute testing session to take the achievement test and cognitive tests. After this session, the

manual for the game, a list of the teaching moves, and a direction sheet were given to each subject, and a time was set for the game session.

Game session. In the game session, each subject taught two practice "students" before teaching four experimental "students." Practice and experimental students differed only in the specific knowledge that high and low knowledge students possessed at the beginning of a teaching session. The high knowledge, fast learner from the practice students was always taught first, and the low knowledge, slow learner was taught second. The four experimental students (one of each student type) were taught in random order with all 24 possible sequences represented across subjects.

Interview. After the game, each subject was interviewed by the experimenter, told of the purposes of the study, and paid $10 for participating.

Results

Teaching Variables

The raw data provided by the game were the sequences of teaching moves made by the teachers in teaching each student type and the student's responses to questions. The primary variables for analysis were 15 frequency variables and one ratio variable describing aspects of the teaching sequences. The variables are described in Table 4; the means and standard deviations are given in Table 5. Initial analyses treated data from each experimental student for each teacher as independent observations (N = 128). For later analyses, averages across students for each teacher (N = 32) served as basic data. Since intercorrelations

TABLE 4

Teaching Variables

Variable Name	Aspect of Teaching Measured	Variable Definition
Total Moves	Quantity of teaching behavior	Total number of teaching moves used
Range of Statements	Diversity of statements used	Number of different statement moves used
Higher-Order Questions	Teacher inquiry emphasizing student comprehension	Number of higher-order question moves used
Rules	Teacher emphasis on statement of rules	Number of rule moves used (questions and statements)
Relationships	Teacher emphasis on relationships underlying rules	Number of relationship moves used (questions and statements)
Examples	Teacher emphasis on applications	Number of example moves used (questions and statements)
Percent Correct Student Response	Proportion of questions the student answered correctly	Ratio of correct student responses to total question moves
Topics Initiated with Questions	Teacher use of inquiry in introducing topics	Number of times a teacher initiated discussion on topics with question moves (string of two moves on the same topic necessary for inclusion)
Topics Initiated with Rules	Teacher use of statements of rules immediately in introducing topics	Number of times a teacher initiated discussion on topics with rule moves (questions or statements; string of two moves on the same topic necessary for inclusion)
Topics Initiated with Relationships	Teacher emphasis on relationships underlying rules in introducing topics	Number of times a teacher initiated discussion on topics with relationship moves (questions or statements; string of two moves on the same topic necessary for inclusion)

TABLE 4 (Continued)

Variable Name	Aspect of Teaching Measured	Variable Definition
Teacher Response with Higher-Order Questions	Teacher tendency to continue interaction with the student with an emphasis on student comprehension	Number of times a teacher followed student responses with higher-order questions
Teacher Response with Rules	Teacher tendency to follow interaction with the student with an emphasis on statement of rules	Number of times a teacher followed student responses with rule moves (questions and statements)
Teacher Response with Relationships	Teacher tendency to follow interaction with the student with an emphasis on relationships underlying rules	Number of times a teacher followed student responses with relationship moves (questions and statements)
Changes in Topic	Integration of concepts and principles by the teacher	Number of times a teacher changed topic (e.g., volume to Boyle's Law to Charles' Law)
Interaction	Amount of teacher interaction with the student	Number of times a teacher changed from using statement moves to question moves and vice-versa
Verbal-Symbol	Teacher emphasis on the relationship of algebraic representation to verbal statement of rules and relationships	Number of times a teacher changed from using moves involving verbal statement (questions and statements) to moves involving algebraic representation (questions and statements) and vice-versa

TABLE 5

Means and Standard Deviations for Primary Teaching Variables

Variable Name	Mean	Standard Deviation (N = 128)	Standard Deviation (N = 32)
Total Moves	61.2	24.6	18.4
Range of Statements	25.8	8.0	6.9
Higher-Order Questions	16.4	8.9	6.8
Rules	3.7	3.0	1.4
Relationships	8.8	5.1	3.7
Examples	6.2	4.5	3.7
Percent Correct Student Response	0.85	0.14	0.09
Topics Initiated with Questions	3.9	4.2	3.5
Topics Initiated with Rules	1.7	3.0	2.7
Topics Initiated with Relationships	2.1	2.0	1.6
Teacher Response with Higher-Order Questions	9.2	6.3	5.0
Teacher Response with Rules	4.5	3.5	3.0
Teacher Response with Relationships	6.2	4.5	3.3
Changes in Topic	15.1	9.5	6.6
Interaction	26.1[a]	12.5	8.8
Verbal-Symbol	25.8[a]	10.2	8.9

[a]Actual interaction with the student and verbal-symbol changes are one-half of the measured amount due to the way the variables were defined in the computer program generating the variables.

TABLE 6

Summary Teaching Variables, Intercorrelation Matrix (N = 32)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Total Moves	--	.71**	.80**	.17	.77**	.79**	-.02	.58**	.26	.45*	.74**	.49**	.70**	.63**	.41*	.84**
2. Range of Statements		--	.38*	.41*	.76**	.82**	.34	.15	.27	.38*	.34	.22	.48**	.39*	.12	.62**
3. Higher-Order Questions			--	.24	.56**	.52**	-.32	.60**	.09	.41*	.89**	.22	.79**	.42*	.54**	.50**
4. Rules				--	.27	.19	.32	-.14	.25	.04	-.18	.30	-.00	.23	.00	.28
5. Relationships					--	.62**	-.11	.23	-.03	.63**	.48**	.17	.66**	.41*	.42*	.56**
6. Examples						--	.17	.37*	.20	.47**	.49**	.17	.53**	.44*	.27	.66**
7. Percent Correct Student Response							--	-.32	.48**	-.28	-.23	.15	-.18	-.04	-.40*	.20
8. Topics Initiated with Questions								--	.39*	.13	.67**	.48**	.33	.66	.14	.49**
9. Topics Initiated with Rules									--	-.36*	.17	.64**	-.04	.34	-.30	.40*
10. Topics Initiated with Relationships										--	.28	-.12	.59**	.26	.46**	.18
11. Teacher Response with H-O Questions											--	.26	.71**	.45*	.30	.55**
12. Teacher Response with Rules												--	.24	.56**	.02	.42*
13. Teacher Response with Relationships													--	.31	.59**	.53**
14. Changes in Topic														--	.17	.43*
15. Interaction															--	.23
16. Verbal-Symbol																--

*$p \leq .05$, $r \geq .35$. **$p \leq .01$, $r \geq .46$.

TABLE 7

Ratio Teaching Variables

Variable Name	Aspect of Teaching Measured	Variable Definition
Inquiry	Teacher questioning	Ratio of question moves to total moves
Percent Higher-Order Questions	Same as Higher-Order Questions	Ratio of higher-order question moves to total question moves
Percent Rules	Same as Rules	Ratio of rule moves to total moves
Percent Relationships	Same as Relationships	Ratio of relationship moves to total moves
Percent Examples	Same as Examples	Ratio of example moves to total moves
Teacher Response - Percent Higher-Order Questions	Same as Teacher Response with Higher-Order Question	Ratio of Teacher Response with Higher-Order Question to total question moves
Percent Topics Initiated with Questions	Same as Topics Initiated with Questions	Ratio of Topics Initiated with Questions to total topics initiated
Percent Topics Initiated with Rules	Same as Topics Initiated with Rules	Ratio of Topics Initiated with Rules to total topics initiated
Percent Topics Initiated with Relationships	Same as Topics Initiated with Relationships	Ratio of Topics Initiated with Relationships to total topics initiated

TABLE 8

Means and Standard Deviations for

Ratio Teaching Variables

(N = 128)

Variable Name	Mean	Standard Deviation
Inquiry	0.50	0.10
Percent Higher-Order Questions	0.52	0.19
Percent Rules	0.07	0.03
Percent Relationships	0.14	0.06
Percent Examples	0.09	0.06
Teacher Response - Percent Higher-Order Questions	0.53	0.22
Percent Topics Initiated with Questions	0.34	0.27
Percent Topics Initiated with Rules	0.40	0.24
Percent Topics Initiated with Relationships	0.39	0.25

(Table 6) among the 16 variables indicated that 12 out of the 15 frequency variables were highly correlated with the total number of teaching moves made, nine ratio variables were generated to control for differences in total quantity of teaching behavior and were included in the initial analyses (see Tables 7 and 8).

Effects of Student Characteristics on Teacher Behavior

To test the effects of student characteristics and teacher characteristics on individual teaching variables, four-factor analysis of variance was applied (Teaching experience x Sex x Student learning ability x Student knowledge). Significant differences in teaching behavior that were due to student characteristics ($p \leq .05$; $F \geq 3.9$; $df = 1, 93$) are reported below; significant differences due to teacher characteristics ($p \leq .05$; $F \geq 4.2$; $df = 1, 28$) are reported in the following section.

For fast vs. slow learners, significant differences in teacher behavior were found for 15 of the 16 primary teaching variables and for four of the nine ratio variables. With only two exceptions, subjects used more moves or a greater percentage of particular kinds of moves with the slow learners than with the fast learners. They initiated new topics with rules a greater percentage of the time with fast learners. In addition, fast learners answered a greater percentage of the questions correctly. Significant differences for ratio variables as well as frequency variables suggest that teachers dealt with fast and slow learners differently. When the student learning rules are considered in detail, the observed differences are partially explained by the learning requirements for different students. Therefore, the nature of the

learning algorithms for fast and slow learners influenced teacher behavior in the game, perhaps in complex ways.

Few significant differences in teacher behavior were found for high vs. low knowledge students and no significant interaction effects on teacher behavior due to student learning ability and student knowledge were found. However, subjects did use more moves, a greater range of statements, and more example moves (both absolutely and proportionally) with low knowledge students.

Relationships Between Teacher Characteristics and Teaching Behavior

Relationships between teacher characteristics and individual teaching variables were studied using analysis of variance (N = 128) and correlational analysis (N = 32). The analysis of variance showed few, but consistent, differences in teaching behavior attributable to teaching experience and to the sex of the teacher. Experienced teachers placed less emphasis on stating rules, began fewer topics with rule moves (absolutely and proportionally), and followed student responses less frequently with rule moves than inexperienced teachers did. In addition, they initiated proportionally more topics with relationship moves than inexperienced teachers did.

Women generally emphasized relationships underlying rules more than men did. Women used proportionally more relationship moves, initiated discussion on topics with relationship moves more frequently (absolutely and proportionally), and used proportionally more example moves than men did.

Correlations among teacher characteristics (sex, teaching experience, age, cognitive abilities, cognitive style, and chemistry

achievement) may be found in Table 9, and correlations between teaching variables and teacher characteristics may be found in Table 10. Correlations between teaching behavior and the sex and teaching experience of the subjects were consistent with the analysis of variance results. Age was negatively correlated with initiation of topics with rules ($r = -.39$) and response with rules ($r = -.45$), reflecting the positive correlation between age and teaching experience ($r = .60$).

Although field independence, reasoning ability, spatial ability, and achievement scores were positively correlated, only field independence and verbal ability showed any correlation with teaching variables. Field independence was positively correlated with the number of comprehension questions used ($r = .50$), while verbal ability was negatively correlated with teacher response with rules ($r = -.35$). Allowing alpha = .10, field independence also was positively correlated with the total number of teaching moves used, response with comprehension questions, interaction with the student, and changes from verbal statement to algebraic representation of rules. Verbal ability was negatively correlated with the range of statements used, the number of examples used, changes in topic, and changes from verbal statement to algebraic representation of rules.

Teaching Styles: Patterns Among Variables

Teaching styles. Average scores on the 16 primary teaching variables were used to identify individuals who used similar teaching patterns. Individual profiles were represented (1) by principal component scores (Guilford, 1965) on three factors representing (a) quantity and diversity, (b) structure, and (c) problem-solving aspects of the

TABLE 9

Teacher Characteristics

Intercorrelation Matrix with Means and Standard Deviations

	Sex	Teach. Exp.	Age	Ability Verbal[a]	Ability Reason	Ability Spatial	Field Indep.	Ach.	Mean	(sd)
Sex (1=M, 2=F)	--	.07	.01	-.08	-.28	-.37*	-.03	-.20	1.5	(0.5)
Teaching Experience		--	.60**	.45*	-.04	.05	.02	.29	34.3	(29.0)
Age			--	.32	.16	.02	.09	.34	25.8	(5.5)
Verbal Ability[a]				--	.22	.05	.06	.34	38.6	(4.8)
Reasoning Ability					--	.44*	.47**	.42*	22.3	(4.3)
Spatial Ability						--	.40*	.33	22.3	(7.8)
Field Independence							--	.15	15.8	(7.1)
Achievement (Gas Laws)								--	8.3	(1.6)

*$p \leq .05$, $r \geq .35$.

**$p \leq .01$, $r \geq .46$.

[a] $N = 31$. A low score for a subject whose native language was Polish is not included in correlations, mean, or standard deviation for verbal ability.

TABLE 10

Correlations Between Summary Teaching Variables and Teacher Characteristics
(N = 32)

Variable Name	Sex[a]	Teach. Exp.	Age	Ability Verbal[b]	Ability Reason	Ability Spatial	Field Indep.	Ach.
Total Moves	.17	.16	-.06	-.23	.09	-.00	.33	.10
Range of Statements	.30	.04	-.06	-.34	.01	.03	.02	.06
Higher-Order Questions	.10	.22	-.07	-.12	.06	.14	.50**	.11
Rules	.14	-.02	-.06	-.05	-.19	-.26	-.28	-.20
Relationships	.29	.17	.09	-.18	-.09	-.03	.11	.18
Examples	.30	.20	.02	-.30	.06	.04	.17	.03
Percent Correct Student Response	.07	-.15	-.07	-.06	.24	-.00	-.05	-.07
Topics Initiated with Questions	-.13	.03	-.13	-.06	.08	.05	.28	-.12
Topics Initiated with Rules	-.21	-.35*	-.39*	-.18	.27	.14	.15	-.05
Topics Initiated with Relationships	.43*	.24	.13	-.02	-.29	-.13	.04	.05
Response with Higher-Order Questions	.11	.23	-.05	-.03	.01	.07	.30	.06
Response with Rules	-.22	-.51**	-.45*	-.35*	.20	.16	.22	-.19
Response with Relationships	.27	.11	-.09	-.19	.03	-.06	.24	.07
Changes in Topic	-.14	-.04	-.25	-.32	-.19	-.08	.00	-.11
Interaction	.16	.14	.01	-.15	-.10	-.26	.32	-.01
Verbal-Symbol	.08	.13	.00	-.33	.16	-.03	.32	.05

*$p \leq .05$, $r \geq .35$.

**$p \leq .01$, $r \geq .46$.

[a] 1 = M, 2 = F.

[b] N = 31. A low score for a subject whose native language was Polish is not included in correlations for verbal ability.

TABLE 11

Rotated Factor Loadings for the First Three Principal Components of the Summary Teaching Variables

(N = 32)

Variable Name	Factors[a] I	II	III
Total Moves	.75	.14	.61
Range of Statements	.66	.61	.24
Higher-Order Questions	.68	-.37	.52
Rules	.12	.72	.02
Relationships	.86	.21	.15
Examples	.71	.35	.33
Percent Correct Student Response	-.22	.79	.06
Topics Initiated with Questions	.19	-.32	.83
Topics Initiated with Rules	-.28	.44	.74
Topics Initiated with Relationships	.80	-.09	-.17
Response with Higher-Order Questions	.54	.31	.62
Response with Rules	-.04	.23	.77
Response with Relationships	.81	-.14	.28
Changes in Topic	.31	.08	.68
Interaction	.65	-.32	-.04
Verbal-Symbol	.51	.33	.59
Percent Variance	43%	18%	13%

[a]Unities in the diagonal.

TABLE 12

Teaching Style Groups

Means and Standard Deviations[a] for Summary Teaching Variables,

Ability Measures, and Gas Law Achievement Test

Variable	Group 1 (N = 6)	Group 2 (N = 6)	Group 3 (N = 6)	Group 4 (N = 4)	Total Sample (N = 32)
Total Moves	47.3 (1.9)	72.0 (6.1)	70.0 (6.5)	33.3 (6.2)	61.2 (18.4)
Range of Statements	21.1 (3.7)	23.8 (2.4)	32.5 (2.9)	17.8 (3.6)	25.8 (6.9)
Higher-Order Questions	13.3 (2.9)	23.2 (2.7)	18.7 (3.3)	5.0 (5.1)	16.4 (6.8)
Rules	3.8 (0.8)	3.5 (0.8)	3.8 (1.3)	3.5 (1.7)	3.7 (1.4)
Relationships	5.7 (2.1)	10.2 (1.0)	13.0 (2.5)	4.0 (3.7)	8.8 (3.7)
Examples	3.0 (1.4)	6.5 (0.8)	9.0 (2.8)	1.5 (1.7)	6.2 (3.7)
Percent Correct Student Response	0.85 (0.06)	0.75 (0.08)	0.87 (0.05)	0.86 (0.08)	0.85 (0.09)
Topics Initiated with Questions	2.7 (2.9)	7.2 (1.5)	2.2 (1.0)	2.0 (1.4)	3.9 (3.5)
Topics Initiated with Rules	2.0 (1.4)	1.2 (0.8)	0.2 (0.4)	2.0 (1.4)	1.7 (2.7)
Topics Initiated with Relationships	0.8 (0.8)	2.8 (0.8)	3.5 (1.5)	0.3 (0.5)	2.1 (1.6)
Teacher Response with H-O Questions	7.7 (2.3)	12.8 (3.3)	8.7 (2.7)	2.5 (2.1)	9.2 (5.0)
Teacher Response with Rules	3.8 (0.8)	5.8 (1.3)	2.8 (2.1)	3.8 (2.2)	4.5 (3.0)
Teacher Response with Relationships	4.0 (2.1)	9.3 (2.3)	8.0 (1.3)	1.8 (1.5)	6.2 (3.3)
Changes in Topic	12.7 (2.3)	15.8 (1.5)	14.2 (5.5)	11.5 (2.5)	15.1 (6.6)

TABLE 12 (Continued)

Variable	Group 1 (N = 6)	Group 2 (N = 6)	Group 3 (N = 6)	Group 4 (N = 4)	Total Sample (N = 32)
Interaction	21.8 (6.2)	34.5 (5.1)	31.2 (5.9)	16.0 (4.2)	26.1 (8.8)
Verbal-Symbol	19.0 (2.5)	27.8 (5.7)	27.7 (4.8)	18.3 (3.5)	25.8 (8.9)
Verbal Ability[b]	40.8 (1.9)	40.3 (5.2)	38.7 (5.0)	38.3 (4.6)	38.6 (4.8)
Reasoning Ability	19.7 (2.0)	24.2 (4.0)	22.3 (3.6)	24.5 (3.1)	22.3 (4.3)
Spatial Ability	22.0 (10.5)	26.3 (6.2)	21.0 (7.5)	24.5 (4.7)	22.3 (7.8)
Field Independence	12.0 (5.4)	23.1 (7.0)	14.0 (9.0)	13.5 (5.6)	15.8 (7.1)
Gas Law Achievement	8.0 (2.1)	8.8 (1.2)	9.2 (0.8)	8.0 (1.8)	8.3 (1.6)

[a]The mean is given first, followed by the standard deviation in parentheses.

[b]A low score for a subject whose native language was Polish is not included in means and standard deviations for verbal ability.

teacher's behavior in the game (see Table 11), and (2) by Chernoff "faces," computer plotted diagrams of faces whose features were determined by individual scores on assigned variables (Chernoff, 1971). Four groups were identified from the main body of teachers by grouping teachers with similar principal component scores or similar Chernoff faces. Means and standard deviations on teaching variables and teacher characteristics for these groups are presented in Table 12. Teaching profiles are presented in Figures 5, 6, 7, and 8.

The two most distinct groups of teachers, i.e., groups identified by both grouping techniques, were:

> Group 1, a deductive, lecture-oriented group (N = 16) who emphasized rules and presented material on each concept or principle before asking questions of the student, and
>
> Group 2, an inductive, question-oriented group (N = 16) who used many questions, particularly comprehension questions, to introduce subject matter and to respond.

Teachers in the deductive, lecture-oriented group received responses that averaged 85 percent correct when they asked questions; and the inductive, question-oriented group received responses that averaged 75 percent correct. These differences in student response reflect a greater use of comprehension questions by the second group and a different use of questions by each group (see Figures 5 and 6). The first used questions more as a check on student knowledge at the end of the discussion, whereas the second often used questions to initiate discussion on a topic not covered yet in the teaching session.

Two other groups were also identified, one by each of the grouping techniques. One was:

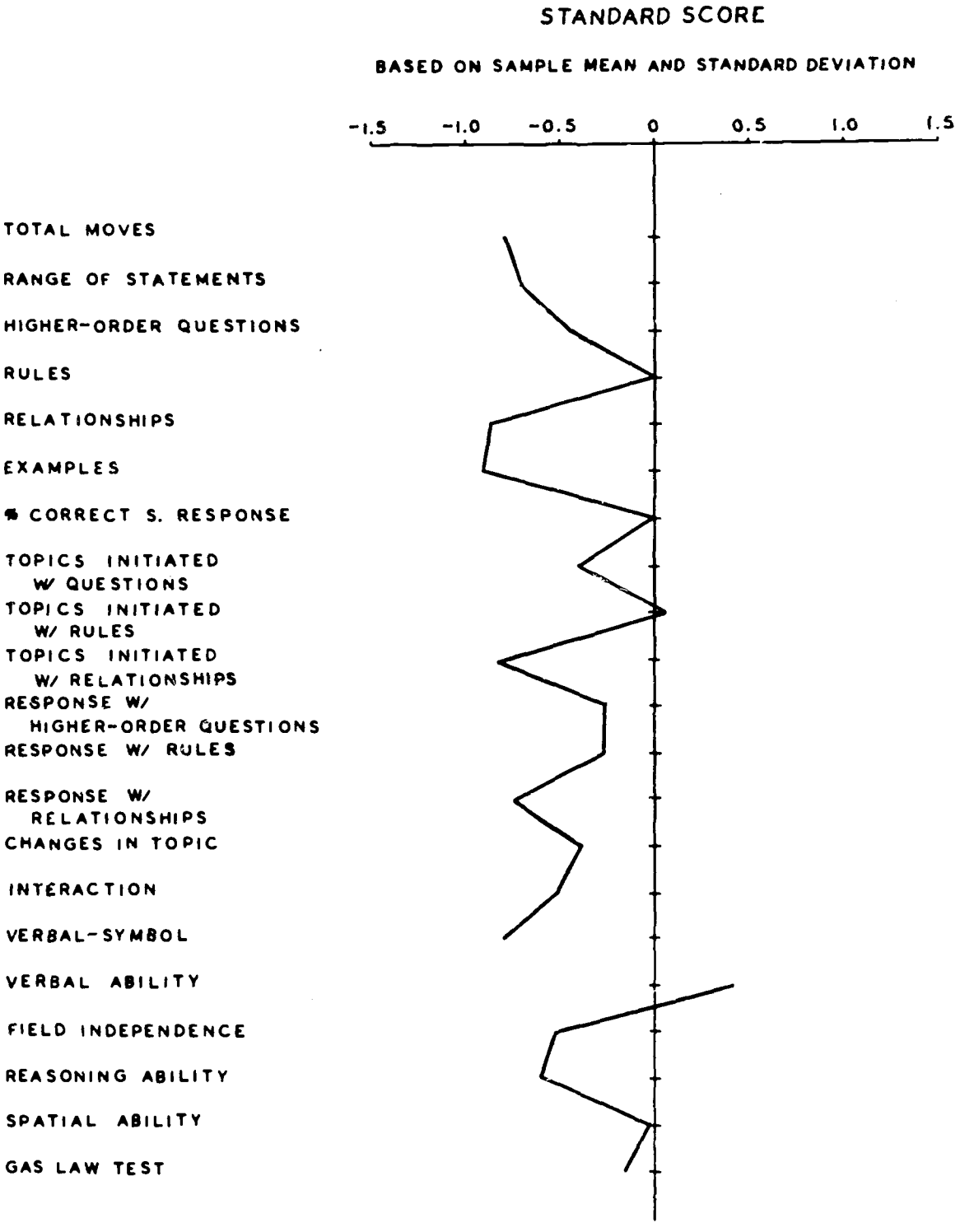


Figure 4. Average teaching profile for Group 1. N = 6.

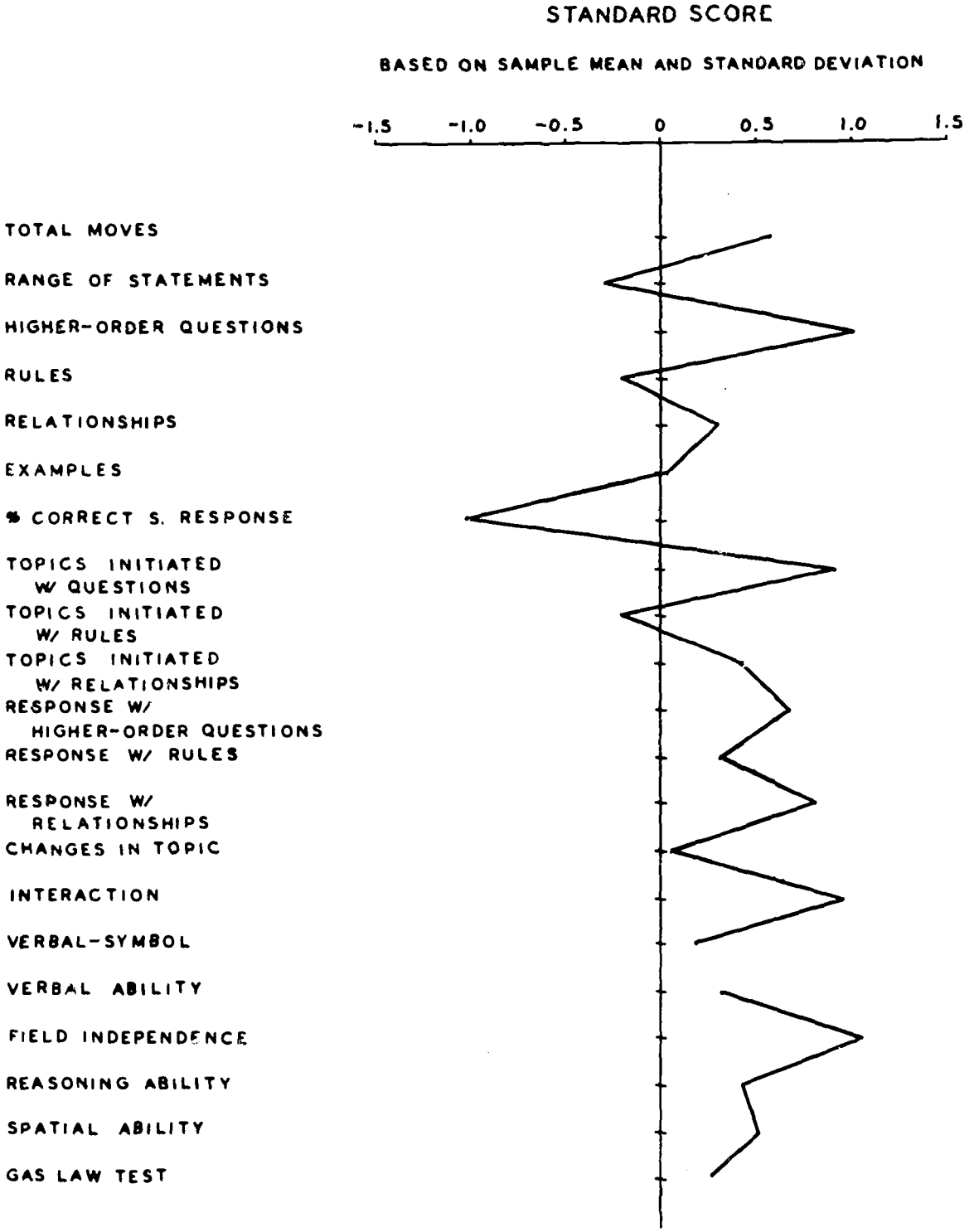


Figure 5. Average teaching profile for Group 2. N = 6.

Group 3, an inductive, lecture-oriented group (N = 6) who emphasized relationships, presented subject matter to the student, but interacted with the student during the presentation by using questions to monitor learning (see Figure 6).

From the interviews after the game, it appeared that the fourth group (N = 4) had been alienated by the teaching game situation. In teaching, they first presented subject matter with a strong emphasis on rules and then asked questions. Their teaching sessions were short and probably represented a minimum of effort on the part of the subjects in meeting the requirements of the game (see Figure 7). The remaining teachers (N = 10) did not fall consistently into any group and shared few teaching characteristics, except that they tended to present subject matter before asking questions of the student (a lecture orientation).

Teaching styles and teacher characteristics. Membership in each of the groups identified did not seem to be related to the age or occupation of the subjects. However, although men and women fell fairly evenly into groups by teaching style, all of the alienated group of subjects were men, and most of the unclassified subjects were women. This uneven distribution of men and women in the alienated and unclassified groups may represent systematic differences between men and women in response to the game or may have been due to chance. All the subjects in the inductive, lecture-oriented group (Group 3) and most of the subjects in the inductive, question-oriented group (Group 2) were experienced teachers, suggesting that a more inductive approach to teaching may be related to teaching experience. However, on the average, both inductive groups performed better than other groups on the achievement measure,

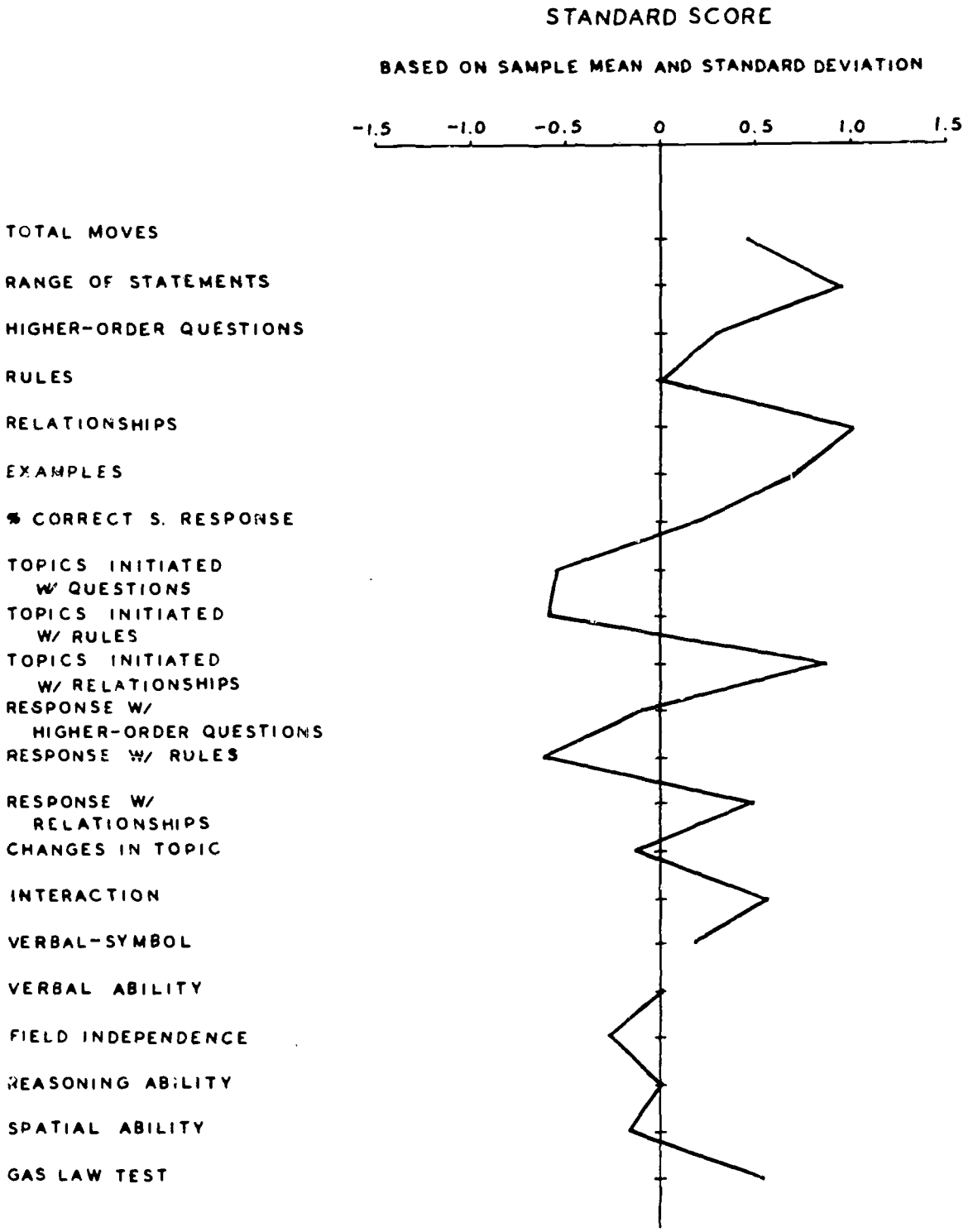


Figure 6. Average teaching profile for Group 3. N = 6.

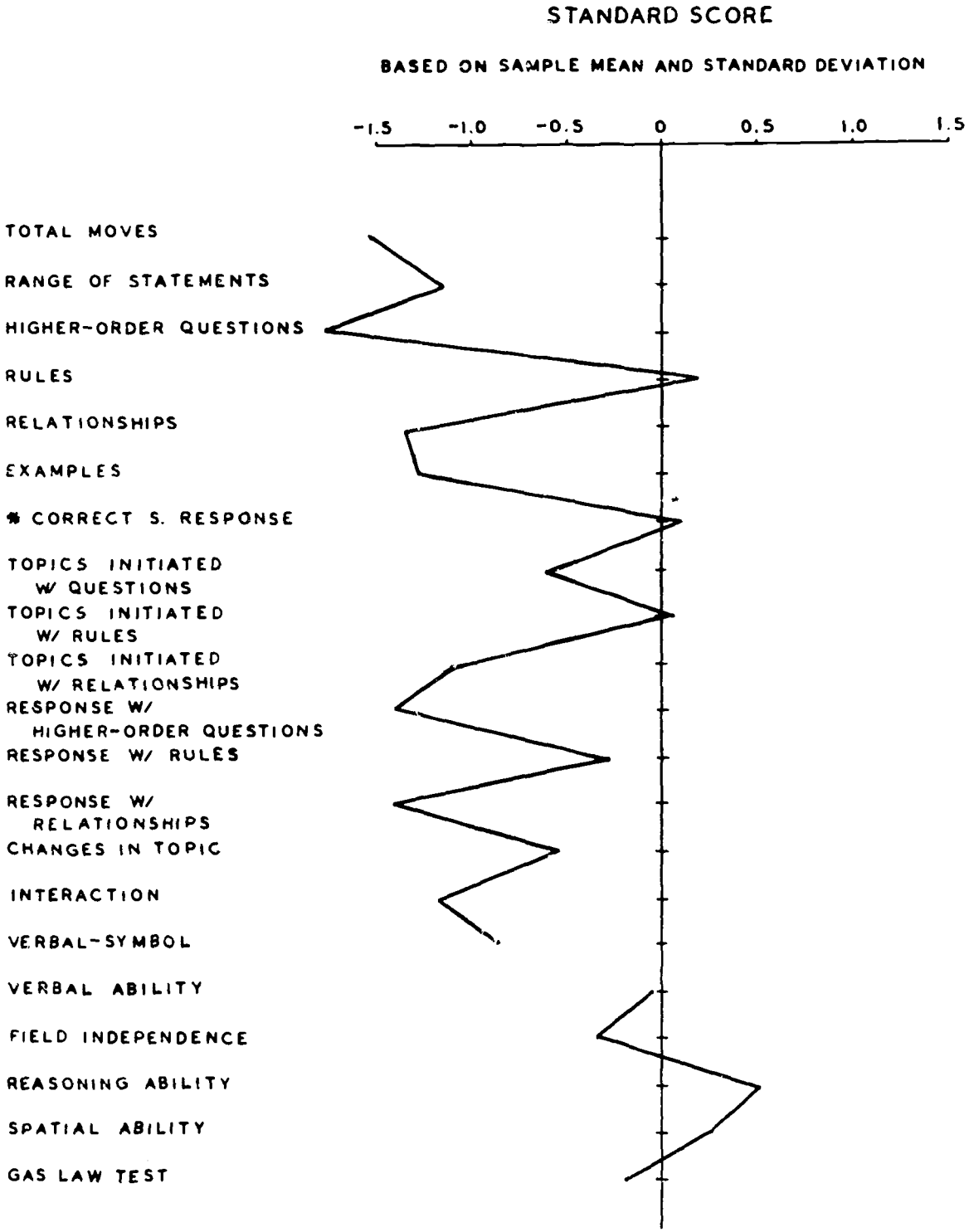


Figure 7. Average teaching profile for Group 4. N = 4.

indicating that they may have been more familiar with the subject matter than other teachers and therefore more able to take an inductive approach.

The groups also differed on cognitive measures, but the meaning of these differences is unclear. Some conjectures will be made here, but such comments are more suggestions for future research than conclusions from this study. On the average, the deductive, lecture-oriented group (Group 1) scored higher on the verbal ability measure than on the other ability measures. This pattern of ability along with their interview comments on feeling restricted by the lack of verbal feedback from the student and by the repertoire of teaching moves may indicate that these teachers rely quite a bit on verbal communication in teaching. The inductive, question-oriented group (Group 2) scored above the sample mean on all the ability measures and particularly on field independence. With their questioning approach, these teachers appeared to be willing to risk incorrect answers from the student and may have modified their teaching sequences more from student to student than other teacher groups. Although on the average the two groups scored the same on verbal ability, the group means on field independence contrasted sharply. The deductive, lecture-oriented group scored lower on field independence, while the inductive, question-oriented group scored higher on field independence.

The group that was alienated by the game situation (Group 4) scored below the sample mean on field independence, but above the mean on spatial and reasoning ability measures. Along with these subjects' interview comments on the lack of visual feedback from the student, this

pattern may indicate that these teachers rely more on visual contact with the student than other teachers. Such a preference may have contributed to their alienation from the game situation, where no visual contact with the student was possible. The inductive, lecture-oriented group (Group 3) and the unclassified teachers scored at or slightly below the sample mean on all the cognitive measures. However, standard deviations were large, suggesting that there was little consistency on cognitive measures for these teachers.

Discussion

Teaching Styles and Educational Implications

The particular teaching styles identified in this study are not surprising. Instead, they support educators' suspicions that many teachers are lecturers, conveying information before interacting with the learner, that some teachers use more inductive approaches to subject matter than others, and that a very few teachers use a highly interactive, questioning approach in teaching. Intuitively pleasing results both lend validity to the teaching game as a situation for assessing teaching style and cast suspicion on the game, suggesting that it may be a vehicle for reaffirming what we already know.

If teaching style is a pervasive characteristic of teachers, then teaching styles may pose major questions for teacher training: To what extent can teaching styles be modified to accommodate particular teaching strategies? To what extent should attempts be made to modify teaching styles? Although many characteristics of the teacher, of the training program, and of the actual teaching situation may influence the

teacher's techniques, the person's natural teaching style may be important in acquiring new techniques. And it may be important for effective teacher training and reliable evaluation of educational programs to be able to identify the teachers who can most readily adapt their teaching style to incorporate particular teaching techniques.

Since the students in this study were simulated, no evaluation of teaching success can be made. Relationships between teaching styles and student achievement will have to be determined under more normal teaching conditions than the game allows. However, even this brief experience with the game suggests that the effectiveness of individual styles may be related to the kinds of students being taught. Interaction of student characteristics and teacher style will be even more probable if teaching style is related to other teacher characteristics. There are hints in this study that teaching style may be related to teaching experience, familiarity with the subject matter, verbal ability, cognitive style, and perhaps sex. For example, one teaching style group scored higher on field independence than the sample in general, while another group scored lower (were more field dependent). Recent pilot research on interaction among teachers who were matched and mismatched with students according to field dependence/independence suggests that the cognitive level of classroom discussion and the amount and nature of teacher-student interaction may be related to the cognitive style of both teachers and students (Witkin, 1972; H. A. Witkin & F. J. McDonald, personal communication, Educational Testing Service, 1973).

Limitations and Potential Strengths of the Teaching Game

There is no doubt that the teaching game, particularly as it stands now, is limited in simulating an actual teaching-learning situation. Visual and affective characteristics of teaching, student feedback other than binary responses, and much of the teacher's verbal behavior are presently omitted from the game situation. This limits the game to particular cognitive aspects of teaching--how the teacher combines questions and statements in presenting subject matter and in interacting with the student. Calibration of the game against actual classroom teaching is an important further step in developing and validating the game.

Despite these limitations, the capability of the game to influence teacher behavior, to allow identification of teaching style groups, and to create an experience subjects could compare with everyday teaching suggests that the game approach is potentially useful for educational research and teacher training. The general model offers many avenues for modifying the game to apply to particular educational problems. In addition, many of the current limitations of the game may be lifted by adding more complex simulation features. Ultimately, computerization may make the game more flexible and lifelike. Computer-assisted instruction in professional training has already begun in medical education. A number of interactive programs based on particular models of decision making exist for training medical students to diagnose certain types of medical problems (Taylor, 1972). The general possibility of simulating teaching experiences holds considerable promise for teacher training.

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