DOCUMENT RESUME

ED 298 945 IR 013 438

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TITLE Teacher as Supervisor of Complex Technology.
PUB DATE Apr 88
NOTE 55p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 5-9, 1988).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Academic Achievement; *Classroom Environment; Classroom Research; Classroom Techniques; *Educational Technology; Elementary Education; *Learning Centers (Classroom); *Lower Class Students; Observation; *Organizational Effectiveness; Organizational Theories; *Teacher Student Relationship

ABSTRACT

This study tested, in the classroom, the proposition derived from organizational theory that the operation of the classroom organizational system is related to the aggregated achievement gains of the students, or, more specifically, that collective achievement is the product of the interrelationship of the instructional technology, the type of teacher supervision, and the work arrangements among the students. Students from lower socioeconomic family backgrounds in 15 classrooms in 1982-83 and 13 classrooms in 1983-84 used curricular materials in learning centers of five students each. Teachers used a classroom management system designed for the study which assisted them in delegating authority and avoiding direct supervision when students were working cooperatively at learning centers. Students were observed to determine the frequency of their working and talking together, working alone, and disengaging from their tasks, and were tested for achievement. The data showed that an increase in the number of learning centers in operation permitted less teacher supervision and teacher facilitation, while less direct supervision permitted more student working and talking together (or student communication). In addition, student cooperation correlated positively with gains on mathematical achievement tests. These findings are examined in terms of both theoretical applications to classroom organizational theory and practical applications to classroom management. Three figures and three tables are provided. (20 references) (EW)

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TEACHER AS SUPERVISOR OF COMPLEX TECHNOLOGY

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AERA Annual Meeting

New Orleans, LA

April, 1988

Imagine the teacher as supervisor of 30 students who are workers, laboring under crowded conditions. The instructional materials and methods become the technology of the classroom as an organizational unit. The students may work together or they may each carry out tasks in relative isolation. These become the work arrangements. The teacher as supervisor can choose different patterns of authority: direct supervision or delegation of authority to the students.

There is considerable heuristic value in utilizing these organizational metaphors to analyze teaching and learning at the classroom level. If the classroom is conceived in organizational terms, the older work of contingency theorists can be used to make predictions concerning outcomes at the classroom level.

In this paper, we test a general proposition derived from organizational theory: the operation of the classroom organizational system is related to the aggregated achievement gains of students in the classroom. More specifically, collective achievement is the product of the interrelationship of the instructional technology, the type of teacher supervision, and the work arrangements among the students. Test scores aggregated to the classroom level and predicted changes in the distributional properti of these tests serve as measures of organizational effectiveness or productivity.

THEORETICAL FRAMEWORK

Sociologists have defined technology as the set of materials, procedures and knowledge that the organization uses to carry out its work (Hickson, Pugh, Pheysey 1969). Teaching methods and curriculum materials become the technology of the classroom, the organizational unit. Two dimensions of classroom technology are of particular interest in this study: differentiation and uncertainty. Differentiation refers to the number of different elements that are in simultaneous operation within the organization. Uncertainty refers to the nature of the task and the amount of predictability or routineness involved in its performance.

According to the first dimension, differentiation, the technology of the classroom varies from large-batch processing where all the students are carrying out the same task to highly differentiated technology where different students are carrying out different t[illegible]s, using different materials. Let us take as an example of differentiated technology a classroom where children are engaged in manipulative and experimental activities related to concepts of math and science. If the class is organized into six groups of five children each, and if each group is carrying out a different task activity using different manipulative materials, the technology is highly differentiated from the teacher's point of view.

According to the second dimension, uncertainty, classroom tasks vary from routine assignments where students follow previously specified and standardized procedures to highly uncertain tasks where solutions and outcomes are not immediately obvious. Continuing the example above, technology becomes uncertain when students, who are working in small groups using various materials, are also encouraged to hypothesize, use trial and error, and discover scientific principles. This situation is a highly uncertain one from the students' point of view. It is unlikely that they can run experiments or solve problems applying routine strategies only. When the purpose of instruction is conceptual learning, the nature of the learning tasks is inherently uncertain. Uncertainty from the students' point of view represents an important condition under which we derive predictions for the relationship between differentiation, teacher supervision, student task engagement, and collective achievement.

Technology, Authority, and Lateral Communication under Conditions of Uncertainty

According to Perrow (1967), once the technology has become more uncertain, two necessary changes should be made in order to maintain or increase organizational productivity. The first is the need for more delegation of authority to the workers. The second is the need for more lateral communication among the workers. If these changes do not take place, there will be loss of organizational effectiveness.

Perrow (1967) argued that lateral communication helps to deal with exceptional cases when the task is uncertain. Lateral communication also serves to increase the amount of information being processed (Galbraith 1973). In addition, higher level search procedures for problem solutions are associated with increased lateral communication (March and Simon 1958). Thus, lateral communication helps to reduce uncertainty, especially when problems are the kind where "two heads are better than one." Instead of constantly checking with the supervisor, the workers can use one another as resources in accomplishing the task. One cannot assume, however, that all lateral communication is productive. In this theoretical treatment, we refer only to task-related lateral communication. In classroom terms, students who are academically low achievers can greatly benefit from interaction with their more proficient peers. This interaction becomes especially important when the low achievers face, what are for them highly uncertain tasks, such as reading instructions to the task, completing worksheets, and calculating.

Derivation of Hypotheses

A highly differentiated technology could lead to several alternative methods of supervision. From the teacher's point of view and according to organizational sociologists, one alternative is to use direct supervision; the teacher can manage and guide the students' behavior through detailed rules and schedules. However, this solution assumes that the workers are facing tasks that are relatively certain. Comstock and Scott (1977) summarized this argument: "When work is predictable, effectiveness and efficiency are enhanced by the development of clear decision rules and operating procedures that allow minimal discretion to individuals. But when work is not predictable, performance programs cannot be developed, and individuals must be called upon to make the best judgments of which they are capable" (p.177). When different groups of workers are carrying out different and uncertain tasks, it is more efficient if they have a clear sense of authority and can make their own decisions, and can learn from their own mistakes. Therefore, under conditions of uncertainty, differentiation will be associated with delegation of authority.

In classroom terms, when groups of students are working on different tasks, the teacher cannot be everywhere at once --although some teachers will attempt to do so. Given a challenging curriculum delivered in a small group setting, it is necessary that teachers not rely exclusively on direct supervision, i.e., telling students exactly what to do, when and how to do it. When the tasks are discovery tasks and students work in small groups at learning centers --after an initial orientation and before a final wrap-up, it becomes obviously inappropriate for teachers to be lecturing to small groups of students or to the class as a whole. Empirically, however, we have found that unless they have been adequately trained, teachers will attempt to do so. At times, teachers will also try to reduce student uncertainty by using detailed and overly explicit worksheets in which students "fill in the blanks." The objective of conceptual learning, however, cannot be attained by tasks of such mechanistic nature.

Adequate training is necessary for teachers as well as for the students. If students are expected to work effectively in small groups, systematic training is required. Cooperative norms in the classroom and students using each other as resources to accomplish uncertain tasks represent an entirely new set of behaviors. One cannot assume that children (or adults) naturally know how to cooperate (Cohen 1986b).

Bossert's observational study (1979) suggests that highly differentiated task structures are associated with a reduction in direct supervision. He showed that the same teachers used their authority quite differently when they employed different task structures. He concluded on the basis of his observations:

> The task, then, by determining the size and publicness of the work group, influences the extent to which inappropriate behavior is visible to the teacher and fellow pupils. In a large group situation, like recitation, the opportunity for misbehavior to spread increases, as does the teacher's

> ability to detect misbehavior. This, coupled with the necessity for pupil attention in recitation, establishes a situation in which control becomes of prime importance. (Bossert 1979, pp.51-2).

Steven H. Rosenholtz (1981) found that direct supervision had a positive effect on task engagement only when fewer classroom groups and fewer classroom materials were utilized. Rosenholtz compared classrooms that varied in the number of different groups and materials in simultaneous use. He found that direct supervision by the teacher was positively related to engagement only under conditions of fewer groups and materials. When the same teachers used multiple materials and groups, direct supervision was unrelated to the level of engagement. When the technology was more differentiated, the use of peer relations (an indicator of delegated authority for Rosenholtz) was a powerful predictor of engagement.

The empirical evidence of the effect of differentiation on teacher supervision and the impracticality of direct supervision in the face of differentiated technology, which is uncertain from the workers' point of view, leads us to the first hypothesis.

> Hypothesis I: Given uncertainty of the task from the students' point of view, when the technology of the classroom is more differentiated, the teacher is less likely to use direct supervision (the obverse of delegation of authority).

Given students' engagement in uncertain task activities, the extent to which the teacher applies direct supervision will diminish the possibilities and opportunities of students communicating with each other. If the teacher is moving from group to group, supervising students and telling them what to do, she will undermine and "short circuit" student interaction. If the teacher, an authority figure, takes responsibility for their task engagement, students will not assume responsibility for solving problems related to the task. In other words, if a teacher continually tries to facilitate completion of the task, to provide elaborate explanations, and to prevent students from making mistakes, the students will be less likely to talk with each other about their task.

As mentioned above, if the materials and the tasks contain many exceptions and are thus highly uncertain, Perrow (1967) states that both delegation of authority and lateral communication are necessary for achieving and maintaining organizational effectiveness. We argue that there is a causal connection between delegation of authority and lateral communication, such that lateral communication cannot be established and maintained in the face of direct supervision.

> Hypothesis II: Given uncertainty of the task from the students' point of view, the more frequently the teacher uses direct supervision, the lower will be the rate of lateral communication among students.

When classroom technology is uncertain, the extent to which students talk and work together will be related to organizational effectiveness. Let us consider again the example of the classroom described above. Suppose that in this classroom with six groups of students carrying out discovery activities in math and science, many children cannot read and write, and some of them do not share a common language with their classmates. In addition to the inherently uncertain nature of the tasks, there is uncertainty over understanding written task instructions and over communication with others.

Under these conditions, if the children use each other as resources by reading, explaining, and showing to each other how to do the tasks, the interaction will serve to reduce uncertainty. When uncertainty is reduced in this manner, more learning takes place than if each child uses only the resources at his or her individual command. It is important to note, however, that the curricular materials need to be well designed so as to facilitate student communication. Well engineered materials might include instructions in more than a single language, illustrations, and manipulatives, thus providing alternative means of communication.

Using learning gains as an indicator of organizational effectiveness, we can derive the third and extremely important hypothesis from the theory concerning the effects of worker communication, under conditions of task uncertainty.

> Hypothesis III: Given uncertainty of the task from the students' point of view, the extent to which students talk and work together will be positively related to the average gains on achievement tests, particularly on measures involving conceptual learning and problem-solving.

In an analysis of data from classrooms such as the one described above, Leechor (forthcoming) found that students with very low achievement scores in reading benefited more as a result of talking and working with their peers than students who were initially closer to grade level. Thus, lateral communication is particularly effective in reducing the uncertainty of the task for students with minimal academic skills. Based upon this finding, we predict that lateral communication will be related not only to improved average achievement scores, but also to a reduced variation in the distribution of post-test scores when compared to the distribution of pre-test scores. In other words, if it is the case that the those students who had the lowest performances on the pre-test scores are as able to benefit from the learning materials as are those who have higher scores, we assume that the net effect will be to reduce the variance of the distribution of the post-test scores. This argument leads to a corollary of the third hypothesis.

> Corollary: Given uncertainty of the task from the students' point of view, the extent to which students talk and work together will be positively related to a reduction in the variation of the distribution of the pre-test achievement scores when compared to the variation of the distribution of the post-test scores.

This third hypothesis assumes that the task activities used by the students are well designed and relate to the criterion test that is being used to measure learning gains. If this is the case, talking and working together in a classroom can reduce student uncertainty in many ways. If one student understands the written instructions to the activity, she can show another student how to do things. If another student knows how to put the equipment together successfully, he can help someone else who doesn't. Even if this interaction is not necessarily high-level discussion, it can function to assure that all students have access to the learning task chosen by the teacher.

FIGURE 1 ABOUT HERE

Figure 1 is a graphic representation of the theoretical model presented. The figure can be used to analyze the relationship between pairs of variables as well as to develop a path analysis. First, we test hypothesized relationships between pairs of variables with correlations. In addition, our theoretical discussion implies a causal model which we test with a path analysis.

At this point, it is important to consider an alternative explanation for the hypothesized effect of lateral communication on learning. An extensive body of educational literature dealing with the individual level posits time-on-task as a predictor of learning gains (Anderson . 81). It is possible that a measure of lateral communication relates to learning gains because it is also an indicator of time-on-task. One could argue that classrooms where more students are talking about their tasks are simply classrooms where there is more student engagement. In order to counter this alternative explanation, we will include an additional indicator of time-on-task: working alone. We will examine the effect of working alone on achievement gains. In addition, we predict that controlling on this :sure at the classroom level will not eliminate the effect of lateral nication on learning gains.

SAMPLE OF CLASSROOMS AND SETTING OF THE STUDY

Researchers from Stanford University's Program for Complex Instruction have made extensive studies of an instructional technology such as the one described above. This technology is differentiated from the teacher's point of view; learning activities are highly uncertain from the students' point of view. The goal of the curricular materials when delivered through this instructional technology is to further the development of thinking skills in early elementary school students; concepts of science and math are embedded in discovery and problem-solving activities. Program staff have collected observational and achievement data from two different sets of classrooms using this technology and the curricular materials in two different school years. Although the sample size of classrooms is small in each of the two years, these data permit two independent tests of the three hypotheses and the corollary of this study.

A Differentiated and Uncertain Technology

The curricular materials employed in the sample of classrooms in this study are called Finding Out/ Descubrimiento and were developed by Edward DeAvila and his associates for bilingual settings. In a typical classroom of thirty students, there are six or seven learning centers -- no more than five children per center. Each center has a different task activity. At each learning center, there are two illustrated activity cards describing the task, various manipulatives, and a worksheet for each child. One activity card has instructions in English and the other has instructions in Spanish. In its ideal form, Finding Out/ Descubrimiento represents a highly differentiated technology. Training teachers how to install and maintain this differentiation, i.e., multiple learning centers in the classroom, is a major feature of the preparation of teachers for program implementation.

All students in the group must complete the activity at each learning center as well as the accompanying worksheet. The questions on the worksheets are demanding, asking young children to write or draw what happened. In the science activities, students are asked to hypothesize why and how scientific phenomena occur. In math activities, they estimate possible outcomes, measure, calculate, plot outcomes, and record results. Typically starting in November and running through May, children spend about an hour a day, four days a week on these activities.

Evaluations of the relationship of observed behavior to learning gains suggest that children show gains on standardized achievement tests of reading and math because they read, write, compute and solve word problems in an intrinsically interesting and meaningful context (Cohen and Intili 1981). Analyses of pre- and post-test scores on CTBS Reading and Mathematics consistently show statistically significant gains relative to the national norm population for Grades 2,3, and 4 (Cohen and DeAvila 1983; Bogler and Leechor 1987). They also show statistically significant gains in the CTBS science sub-test (Cohen and DeAvila 1983). Many of the math activities of the curriculum are directly related to specific items on the standardized achievement test, e.g., using the metric system and its scales, principles of measurement, using coordinates, and graphing. In addition, the applications of arithmetical problems in concrete experiments and meaningful contexts help students understand the concepts underlying computational items of the test.

In addition to representing a differentiated technology, the Finding Out/ Descubrimiento materials can also be described as highly uncertain from the children's point of view. Uncertainty stems mainly from the conceptual nature of the tasks. Given the characteristics of the population of this study, uncertainty also stems from the weak academic skills of the students in the classrooms studied, as they cope with the reading and writing required by the activity cards and worksheets.

The Sample

Children in the sample are from lower socioeconomic family backgrounds; generally, many of these children have little access to science and limited exposure to higher order concepts in mathematics. Classes in the sample contain large percentages of students with limited English proficiency. Many of them test as "limited proficient" in both English and Spanish. Test scores on reading and language arts average at the thirtieth percentile and below.

The data are drawn from classrooms in Grades 2-6. In the classrooms of our sample, there were two adults in each classroom, typically a teacher and her aide. Running six learning centers with different activities and with students who may have difficulty understanding instructions is a complex task from the teacher's point of view. Therefore, the Program strongly recommends that there be two adults who operate as a team in the classroom. The teacher and her assistant are trained to work together as a team. The assistant spends most of her time asking questions and making sure that groupmates are cooperating. Often, the assistant takes care of logistics and deals with problems generated by the use and organization of the hands-on materials.

Classroom Management Strategy

The staff of The Program for Complex Instruction at Stanford has developed and researched a classroom management system designed for classrooms using differentiated and uncertain technology. The purpose of this management system is to help teachers delegate authority and to avoid direct supervision when students are working cooperatively at learning centers. This management system, then, could be used for various cooperative learning curricula as well as for activity-based science classrooms. All the teachers who participated in this study took part in a standardized training program which included two weeks of instruction in the summer and a year-long follow-up program. We have documented the effectiveness of this training program in helping teachers to delegate authority, i.e., maintain multiple learning centers with approximately five children per center (Cohen and De Avila 1983).

When teachers use the recommended classroom management system, they assign students to heterogeneous groups to work at the learning centers. The groups are heterogeneous as to language proficiency, academic skills, and gender. Bilingual students are particularly valuable resources in their groups. They are trained to act as translators between their groupmates who do not share a common language, and sometimes between the teacher and the non-English proficient children.

Usually, groups stay together for the duration of a curriculum unit, one or two weeks. By the end of the school year, each student will have had the opportunity to work with all the other students in the class.

Students learn to work cooperatively by playing a set of especially designed cooperative games. These games serve to introduce students to new norms for classroom behavior and to provide opportunities for practice for those new behaviors. In a chapter of a handbook written for teachers, Lotan and Benton (forthcoming) give an extended example of how the classroom management system functions to keep the children on task.

> At the learning centers, the children take full responsibility for their own and their groupmates' engagement and learning. The children know that they cannot move on to the next learning center unless all group members have completed the task and their worksheets. (The classroom management) system allows children to manage and monitor their interactions at the learning centers. For example, children have the right to ask one another for help when they do not understand a step in the task; children who seem to understand have the duty to provide assistance. Children attempt to explain to each other what the task entails and why certain things might be happening. When turns need to be taken, children are concerned that everybody in their group gets the opportunity to contribute. (Lotan and Benton, forthcoming)

In addition to introducing and reinforcing cooperative norms, the teacher is instructed to assign various roles to the students in the group. The use of roles does much to assist the teacher in delegating authority while assuring control of task-related behavior among students. There is less need for teachers to tell students how to perform their tasks and to watch them so that they stay on task. Roles assigned to students work to keep all group members on task.

Lotan and Benton describe the operation of the roles as follows:

> The facilitator has the responsibility of seeing to it that everyone in the group understands the instructions on the activity card that the children share at the center. The facilitator also is the one who seeks help from the teacher when the group cannot solve a problem. The checker makes sure that all of the worksheets are completed. The clean-up person supervises the group as it puts away all the materials at the end of learning center time. The reporter summarizes the work accomplished by the group and comments on the way groupmates worked together. The safety officer makes sure that students take the necessary precautions in using the manipulatives at the learning centers, from striking matches and pouring water, to cutting with knives and using ammonia. (Lotan and Benton, forthcoming)

Theoretically, the system of norms and roles helps the teacher to maintain control as an authority in the classroom. (See Cohen 1986b) There is much less need for teachers to tell students how to perform their tasks and to watch them so that they stay on task. Due to the operation of norms for cooperation, students assist each other in completing the task and worksheet instructions. The roles work to keep all group members on task.

Ideally, teachers hold the students accountable through the demand for completion of worksheets. By studying the day's worksheets, the teacher can determine the quality of the students' understanding of the underlying concepts, as well as the nature of any potential conceptual confusion. The teacher can then target problematic areas for special attention in the daily whole class orientation, prior to the session at learning centers. The daily orientation and wrap-up call for large-group substantive instruction combined with discussion, higher order questioning and demonstration of scientific and mathematical principles. During wrap-up, the reporter from each group typically describes what the group discovered.

During the initial and final periods of the lesson, i.e., the orientation and the wrap-up, the teacher uses direct supervision, or what is today called direct instruction. It is when the students are working in small groups at the learning centers that the teacher is given a new and different role to play. Moving from center to center, the teacher facilitates the interaction, helping students with their work and giving information only when absolutely necessary. Often, the teacher asks questions that stimulate and extend students' thinking about their tasks, provides feedback and promotes further discussion and investigation. The teacher also pays particular attention to low status students, addressing status problems that inhibit student learning. (For a detailed description and analysis of this last point see Cohen, Lotan and Catanzarite, 1988). Thus, the ideal teacher role is a combination of direct supervision and delegation of authority, depending on the nature of the task.[1]

DATA COLLECTION AND MEASURES

Two sets of data were analyzed for the purposes of this study: the first set was gathered during the academic year 1982-83, and the second during 1984-85. For 15 classrooms in ten schools in 1982-83, and for 13 classrooms in five schools in 1984-85, Program staff collected systematic observations on the teacher and on the classroom. Standardized achievement scores were available for 11 classrooms in the 1982-83 data set, and for 12 classrooms in the 1984-85 data set. Using the teacher observation instrument, observers scored the teacher for frequency of

1. The distinction between delegation of authority and direct supervision is in no way equivalent to the older distinction in the literature between authoritarian versus democratic teaching styles.

selected behaviors for ten minute intervals. While the curriculum was in operation, the teachers were observed repeatedly, approximately ten times each in 1982-83 and 20 times each in 1984-85.

In 1984-85, we made ten separate observations when the teacher was conducting orientations or wrap-ups, and when the students were at learning centers. In 1982-83, the ten teacher observations were a mixture; some observations were taken during orientation/wrap-up and others were taken while the children were at learning centers.[2] Some of the categories of teacher behavior captured by the observation instrument relate to direct supervision. Most central of these is the variable labelled "teacher facilitates." Facilitation includes telling students how to get through the task. It may include procedural questions such as, "Did you read the activity cards?", "What do the instructions tell you to do next?" Other variables on the teacher instrument relevant to direct supervision are: instructs, asks substantive questions, and disciplines. Inter-scorer reliability is measured by the percentage agreement based on a comparison of scoring by rater and supervisor. Reliability on the teacher observation instrument was 91% in 1982-83, and 91.48% in 1984-85.

Measures of differentiation and of lateral communication between students were taken from an instrument called the whole class instrument. This instrument consists of a grid representing grouping and activity patterns of students in the classroom. The observer counts the number of students engaged in various activities at the learning centers and sometimes away from the learning centers.

2. In the 1982-83 data set, we had not realized the importance of the effects of differentiation on the teacher's behavior.

The number of different learning centers in operation is also recorded. This instrument is like a snapshot of all the students and the teacher(s) in the classroom at a given point in time. In both data sets, there are approximately twenty measurements of each classroom, always taken when the children were working at learning centers -- after the initial orientation and just before clean-up time. The overall average reliability for all categories on this instrument was 90% in 1982-83, and 95.54% in 1984-85. Using the whole class instrument, average differentiation is indicated by the number of learning centers in operation, divided by the number of students in the classroom, averaged across all observations. The name of this measure is "Ratio of Learning Centers to Students" (Ratio #LC's/ Students). There were typically five students to a center, but sometimes, teachers used fewer centers and larger groups, or more centers and smaller groups.

The whole class instrument also provides a measure of communication about the task among students. The number of students who were talking to each other about the task, or talking about the task while manipulating the materials were counted. The index of lateral communication is the average proportion of children so engaged in the classroom (%Talk/Work Together).

In the 1984-85 data set, however, despite a high reliability on the instrument as a whole, the observations for the number of students talking and working together were unreliable. After data collection was completed, we found statistically significant differences between observers on the variable called %Talk/Work Together. Therefore, for the 1984-85 data set, lateral communication is measured by averaging observations taken from a third instrument, the target child instrument. A subset of approximately ten target children in each classroom was observed for three minutes at a time, approximately ten times while the children were working at learning centers. They were scored for frequency of all task-related talk to their peers as well as the number of times that they were seen working together with their peers. The overall reliability for this instrument in 1984-85 was 92.9%. The average total frequency with which target children were observed to exhibit these behaviors ("TC Talk/Work Together") was calculated for each child. Then an overall average of the variable was calculated for each classroom.

Another relevant variable from the whole class instrument was the percentage of students working alone at the learning centers. This variable was used in similar fashion in the analyses of both data sets. Percentage of students working alone is an additional indicator of time-on-task. As discussed in the theoretical framework, this variable was used as a control.

An additional variable taken from the whole class instrument was the percentage of students disengaged from their tasks, whether at the learning centers or wandering and playing elsewhere in the classroom. As the average proportion of disengaged children in a classroom grows larger, one can argue that time-on-task, as a classroom characteristic, is diminishing.

The achievement test data consisted of gain scores from fall to spring on the CTBS (Comprehensive Test of Basic Skills) concepts and application, and computation sub-scales. Only those students who took the English CTBS in fall <u>and</u> in spring were included in the sample. Thus, those students who moved away during the school year, those who transferred into the school after the fall testing date, those whose English was judged insufficient to take the examination in the fall, and those who were absent on either test day were omitted. The 1982-83 achievement data are in percentile scores while the 1984-85 data are standardized scale scores. A detailed examination of the test scores showed that given the content of the curriculum, fifth and sixth graders gained less than the younger students. To eliminate the effects of grade on gain scores, in the 1984-85 data set, gain scores were standardized by grade. Change in the achievement scores was described with two statistics: the average gain of students per classroom, and the difference in the coefficients of variation of the pre-test score distributions and the coefficients of variation of the post-test distributions per classroom.

An individual student's gain score was calculated by subtracting the pre-test from the post-test score. Individual student gains were then averaged to the classroom level. Our second measure of achievement, the coefficient of variation ($\sigma/\bar{x}$) is particularly useful for purposes of this study since it takes into account both the standard deviation and the mean in a single measure. As we described in the theoretical framework, the reduction of uncertainty through lateral communication should result in a parallel reduction in the gap between the scores of high and low performers in the classroom from fall to spring. This reduction will be reflected in the classroom distributions of post-test scores as compared to the classroom distributions of the pre-test scores.

RESULTS

Descriptive Statistics of Observational Variables

Before proceeding to the test of the hypotheses with correlations and path analysis, it is important to draw a statistical portrait of the classrooms in this study. Although children are talking animatedly and moving about, a trained eye can detect that very few children are disengaged (in 1982-83, for example, it was an average of .5 child per classroom; in 1984-85, it was 1.2 child per classroom). It can also be seen that those children who are moving about the classroom are doing so in a business-like fashion, to get materials or to interview classmates in connection with a task.

INSERT TABLE 1 ABOUT HERE

Table 1 presents the means and standard deviations for observational variables used to test the hypotheses for the two sets of data. Given that there are approximately 30 children in a classroom, the finding that in the two years there is approximately 1/5 of a learning center per child means that there were typically five children per center. The level of differentiation was high in all the classrooms. Nevertheless, there was a small, yet statistically significant variation in this index of differentiation among classrooms. (1982-83: $F=12.127$, $p<.001$; 1984-85: $F=7.379$, $p<.001$)[3] An examination of the means and standard deviations of this measure by classroom suggests that the significant F values are not an

3. In the 1979/80 implementation of the program, when teacher training was less intensive, there was great variation among classrooms in measures of differentiation. Some teachers maintained only three learning centers on the average, while others had nine and more.(See Cohen and Intili 1981)

artifact of a few extreme values: classrooms had different means, yet somewhat similar standard deviations.

Despite efforts of the Program staff to inhibit the teachers from too much facilitation, helping students and telling them how to get through the tasks is a typical behavior for teachers. In 1982-83, the teachers averaged 11.06 facilitation remarks during ten minutes of observation. In 1984-85, an index combined the frequencies with which the teacher was scored for several behaviors that indicate direct supervision while the children were at learning centers: facilitation, instruction, substantive questioning, and disciplining. When these behaviors were added, they came to an average of 35.24 such remarks during a ten minute period. Some teachers asked many short questions, boosting this total considerably. Some questions were higher order questions, and others were not, but the observational category of questioning did not distinguish between the two types. There was considerable variation between teachers in the number of behaviors that indicate direct supervision.

As explained above, there are two ways to estimate the amount and frequency of interaction among the students. One is the percentage of children talking and working together as calculated from the whole class instrument; the other is the frequency with which a given child is observed talking to others about the task, during a three minute interval. The latter measure is calculated from the target child instrument aggregated across students within a classroom. By either criterion, peer interaction was an outstanding feature of the classrooms in this study. As Table 1 indicates, in the 1982-83 data set an average of 31.43%

children were observed talking and working together. Using the average of the individual target children per classroom, the 1984-85 data set also shows a high rate of interaction: the average rate of all peer task-related talking and working together per three minutes was 7.72.

In the 1982-83 data set there were, on the average, 21.04% of children per classroom working alone at the learning centers. The standard deviation of this variable was 7.63 indicating considerable variability among classrooms in the sample. In 1984-85, the average percentage of students working alone was 9.38% and the standard deviation was .16. Despite the acknowledged unreliability of the talking and working together category on the whole class instrument, the data showed that the overall percentage of students talking and working together was somewhat higher in 1984-85 than it was in 1982-83. Project staff observed that in 1984-85, teachers were more receptive to ideas involving cooperative learning. If this were the case, the percentage of students working alone would be lowered in 1984-85, compared to 1982-83. An alternative explanation for the difference between the two data sets could be a possible underestimation by the observers of the percentage of students working alone in the 1984-85 data set. Table 1 also shows the means and standard deviations of the dependent variables in our analyses: gain scores of the math computation, and math concepts and application subscales as well as the average difference in the coefficients of variation of the distributions of the pre-and the post-test scores.

Testing the hypotheses

In this study, tests of the hypotheses take place at the classroom rather than at the individual level. The concepts concerning supervision, lateral communication between workers, and organizational effectiveness are system concepts rather than characteristics of individuals. The measures of organizational effectiveness are the average learning gains made for a whole classroom between fall and spring and the reduction in the coefficients of variation of the distributions of classroom learning gains from fall to spring.

Because the analysis is at the classroom level, sample sizes are small. We do, however, have two independent tests of the same hypotheses in the two sets of classroom data. We are able to test the basic hypotheses (although not always with the same measures) on two different sets of data, from two different sets of classrooms, in different schools and districts.

We present the results of our data analyses in two path model diagrams (Figures 3 and 4), one for each year. The underlying concepts are the same as those presented in Figure 1. In each case the measure indicated is intended as an indicator of the underlying theoretical concept. As explained above, these measures, in some cases, differ in the two sets of data. Tables 2 and 3 present intercorrelations for all variables in the hypotheses for the two years. In Table 2 the number of classrooms is given under each Pearson r; the number varies because some of the classrooms did not use the CTBS tests and had to be omitted from analyses requiring achievement data.

Important differences between years

The measure of direct supervision in the first year is the average rate of teacher facilitation while in the second year it is a combined measure of facilitation, direct instruction, substantive questioning and disciplining (the index of direct supervision). This difference arises because the observations of teachers used for this analysis in 1982-83 included observations during orientation and wrap-up, and observations during learning centers, while the 1984-85 observations included teacher observations during learning center time only. Theoretically, it is preferable to restrict observations to those taken at learning centers only; however, this was not possible for the 1982-83 data set. Because facilitation is a supervisory behavior that usually occurs while children are at learning centers, we selected this variable as most reflective of teacher supervision while children are at learning centers. Therefore, for the first data set, facilitation is the most appropriate indicator of direct supervision during learning centers.

The measure of communication between students in 1982-83 is the percentage of students talking and working together (%Talk/Work Together) obtained from the whole class instrument. In 1984-85, this concept is measured by the average rate of talking and working together of a set of target children within each classroom (TCTalk/Work Together).

Achievement scores in 1982-83 were in the form of percentiles, and the gainscore represents the gain in percentiles. The achievement scores in 1984-85 are gains in standard scale scores, standardized by grade. Measures of differentiation and percentage of students working alone are the same in both years.

Correlational Results

INSERT TABLES 2 AND 3 ABOUT HERE

The hypothesized relationships all show statistically significant correlation coefficients in both sets of data, in the direction predicted. The ratio of learning centers to students (measure of differentiation) is negatively related to teacher facilitation (measure of direct supervision) in 1982-83 ($r=-.50$, $p<.05$) and to direct supervision in 1984-85 ($r=-.55$, $p<.05$). The measures of direct supervision, in turn, are negatively related to %Talk/Work Together (measure of student communication) in 1982-83 ($r=-.43$, $p<.05$) and to TC Talk/Work Together in 1984-85 ($r=-.49$, $p<.05$).

The measures of student communication are significantly and positively related to average gains on the test of Math Concepts and Application (1982-83: $r=.72$, $p<.01$; 1984-85: $r=.52$, $p<.05$). Communication is positively related to gainscores in Math Computation ıly in 1982-83 ($r=.61$, $p<.05$).

There are other correlations of interest in these tables. The measures of direct supervision are significantly negatively related to gains in Concepts and Applications in both years (1982-83: $r=-.48$, $p<.05$; 1984-85: $r=-.75$, $p<.01$). The percentage of students working alone is unrelated to gainscores in either year.

For the test of the corollary of the third hypothesis, we calculated a measure of the reduction in the variation of test scores from fall to spring. This classroom measure is a difference between the coefficients of variation of the pretest scores and the parallel coefficients of variation of the posttest scores. As a result of our calculations, we obtained two such measures for each of the two data sets: one for the math concepts and application sub-scale, and one for the math computation sub-scale. In all cases, the coefficients of variation of post-test scores were smaller than the coefficients of variation of pre-test scores. For both data sets, the relationship between lateral communication and the difference in the coefficients in math computation is in the predicted direction, but not statistically significant (1982-83: r=.28, n.s.; 1984-85: r=.29, n.s.).

In 1982-83, the measure of lateral communication (%Talk/Work Together) was significantly related to the difference in the coefficients of the math concepts and application sub-scale (r=.56, p<.05). In the 1984-85 data, the relationship between the measure of lateral communication (TCTalk/Work Together) and the difference in the coefficients was r=.37, n.s. However, a closer examination of the plot of this relationship (see Figure 2) shows that there is an outlier. When this outlier is eliminated from the analysis, the relationship is considerably strengthened: r=.57, p<.05.

INSERT FIGURE 2 ABOUT HERE

Path Models.

In the path analyses, we are not attempting to model a phenomenon. Rather, we are testing a specific, theoretically driven argument. The statistical procedures used to specify the models are regression analyses, in which all predictors are entered at once, with the most powerful one first. In Figures 3 and 4, the quantities reported over the arrows are path coefficients or standardized regression coefficients.

INSERT FIGURES 3 AND 4 ABOUT HERE

Each diagram represents the theoretical model of a process ending in two sets of gainscores, one for each math sub-test. The variable of percentage working alone is used as a control variable in predicting learning gains.

As predicted, teachers in classrooms with greater differentiation had lower rates of direct supervision. In the path model in Figure 3, there is a statistically significant negative path coefficient (one-tailed test) between ratio of learning centers to students and teacher facilitation ($t=-2.10$, $p<.05$). For the equivalent relationship in Figure 4, there is also a statistically significant negative path coefficient between ratio of learning centers to students and direct supervision ($t=-2.06$, $p<.05$).

Also as predicted, in classrooms where teachers did less direct supervision, a greater percentage of children were observed talking and working together in the first set of data, and children talked and worked together at a higher rate in the second set of data. These results may be inferred from the negative path coefficients between Teacher Facilitates and %Talk/Work Together in Figure 3 (t=-1.71, p=.06) and between Direct Supervision and TCTalk/Work Together in Figure 4 (t=1.798, p=.051). Although the correlation coefficients between measures of direct supervision and student communication were statistically significant, these path coefficients have t values with probabilities of having occurred by chance that are just above the .05 level.

As predicted by the third hypothesis, the more the children talked and worked together, the greater were the average learning gains. The path models show a statistically significant path coefficient between student communication and gainscores on the math concepts and application sub-scales in both years, holding constant the percentage of students working alone. The relationship of students talking and working together to gainscores in computation is statistically significant in both sets of data. The relationship between the gain score and percentage of students working alone, the control variable in these regressions, is statistically significant in 1982-83 (t=2.22, p<.05). Percentage working alone is not a significant predictor of gainscores in computation in 1982-83, but reaches statistical significance in the second data set. We have retained the variable of percentage of students working alone in the path model even when it was not statistically significant because of its theoretical importance as a control.

DISCUSSION

There was general support in the data for the hypotheses of the study. We wish to address, however, several issues of interpretation. First, it should be noted that although differentiation was a negative predictor of direct supervision, the measure of differentiation (Ratio # LCs/ Students) had a restricted range in these data. There were no classrooms with only two or three learning centers, or classrooms with more than seven learning centers.

Secondly, we considered the statistically significant effects of student communication on gain scores in computation somewhat surprising at first. We had expected that the effect of student communication would be much stronger when more conceptual learning was involved. We had reasoned that more conceptual learning (and thus more uncertainty) was involved with the word problems included in the math concepts and applications sub-scale than with the computations sub-scale where students could possibly use routine algorithms to find correct answers to the items on the test. However, an examination of the student worksheets suggests a possible explanation for the favorable effects of communication on the improvement in computation skills. Many of the worksheets call for use of computational skills in connection with applications in meaningful contexts. For example, we found the following question on one of the worksheets: "How many liters do you think the container will hold? How many did it hold? How far off were you?" The student not only practices setting up word problems, but must carry out computations in this context. If a young student receives the necessary help to understand the measurement required in this activity and the formulation of the problem for the worksheet, there will be an opportunity for useful and necessary practice in computation. Furthermore, the student will understand more about the nature of addition and subtraction from this concrete application than from mechanistic drill and practice sessions in the typical math lesson. Thus, we conclude that reduction of uncertainty in the area of computation is equally effective as it is for concepts and applications.

Third, in the path models, not all relationships attain statistical significance. This may be due to small sample size. Nonetheless, in evaluating these results, one should consider some alternative hypotheses that might also explain the achievement gains. Technically speaking, the path models are somewhat deficient in that we could not include other variables felt to be important. With such a small number of classrooms, it was not methodologically sound to use more than two predictors in a regression of learning gains. One obvious alternative hypothesis is that sheer time-on-task is producing the results. However, percentage students working alone included in the regression along with the measure of student communication, did not weaken the effect of talking and working together.

Another possible measure of time-on-task is a negative measure: the percentage of students in the classroom who are disengaged. Disengagement is negatively related to gainscores in the two years. However, only one correlation coefficient reaches statistical significance: the negative relationship of disengagement to gainscores in concepts and applications in 1982-83. In 1984-85, correlations are close to zero. As mentioned above, the average percentage of children disengaged is low in both years.

Another explanation for the average achievement gains might be the number of curriculum units completed in each classroom, i.e., amount of curriculum coverage at the time of spring testing. In the 1982-83 data set, this number has a non-significant relationship to measures of achievement. Controlling for the number of units, however, strengthened the relationship between lateral communication and learning gains. We were unable to replicate this analysis with the 1984-85 data set because we did not have the information about the number of units completed at the time of the spring testing.

Finally, one might suggest that students' achievement gains could be explained by a Hawthorne effect. We argue, however, that given the conditions under which the classrooms in our study operated, such is not the case. School districts contracted for teacher training as part of their standard in-service programs. Neither teachers nor students perceived the activities in their classrooms and relevant to this study as experimental. Over the two years, the program operated in a variety of field conditions. Thus, it seems highly unlikely that observed results were due to a Hawthorne effect.

Theoretical Implications

Organizational theory that relates technology to authority structures and work arrangements is a valuable tool at the classroom level in this and in other research (Cohen 1986). Worker interdependence or the amount of lateral communication is a heuristic way of viewing classroom interaction. This variable property of the classroom is quite distinct from viewing interaction as the individual's experience of talking with others. Most studies of classroom interaction have been primarily psychological.(Webb 1982) What does the individual learner gain from the interaction? Why is talking to someone beneficial to learning? We are making a different argument. Given a technology with a high level of uncertainty, the extent to which learners can use each other as resources will positively affect the amount of learning taking place in the classroom. In this case, interdependence reduces uncertainty by helping students gain access to the task and by providing assistance to those in need.

Empirically, analysis of the relationship of interaction to learning at the individual level yields results similar to those at the collective level. In their analysis of the 1979/80 data set, Cohen and Intili (1981) found that the individual student's rate of talking and working together was related to learning. Navarrete (1985), in an in-depth analysis of a second grade classroom, found that the rate with which individual students sought help, received help, and returned to complete the task was related to their gain scores in reading comprehension. In the data sets described in this study, Leechor (in progress) found that at the individual level, interaction is related to learning. He also found that for those individuals who face greater uncertainty with respect to the task, i.e., those who are behind grade level in reading skills, this relationship is stronger than for those students who are closer to or above grade level.

The relationship of interdependence to learning gains is conditional upon the nature of the instructional technology. It is important to state that we are not making an unqualified assertion concerning student interaction. Instead, the propositions hold when the learning activities create tasks that are uncertain. Such conceptually uncertain tasks are uncommon in many of today's schools where the 'back to basics' movement has brought back large group instruction, rote memorization, and routine seatwork tasks as the principal mode of work. The propositions we have tested in this setting should hold for other curricula and other types of classroom populations, where the level of uncertainty is high.

Practical Implications

Given the current stress in education on direct instruction, the strength of the relationship between students talking and working together and classroom learning gains in two independent tests has practical, as well as theoretical and statistical significance. These results indicate that learning outcomes can be improved by allowing students to use each other as resources.

This is particularly the case for classrooms with diverse populations, where many of the children may have difficulty understanding the teacher's instructions, whether written or oral. Reducing uncertainty in these highly heterogeneous classrooms is a vital technical issue for teachers. When students can use each other as resources, it becomes possible for teachers to introduce higher order thinking skills to disadvantaged students. In the case of challenging science activities, we would hazard the guess that a significant proportion of students from even more middle class populations fail to understand task instructions and could well benefit from peer assistance.

Student talking and working together is not a panacea for classroom improvement. Gaining access to the learning tasks will do no good if those tasks are not well designed and capable of accomplishing learning objectives. Furthermore, practical experience with this classroom management system has led to the conclusion that children need retraining in order to work productively with each other.

The negative relationship between direct supervision and lateral communication illustrates the need for rather extensive teacher retraining. Unless teachers learn new roles, they will unintentionally undermine the source of learning, i.e., the student interaction. Delegation of authority is not a skill currently included in teacher training. It is important that teachers learn how to avoid hovering over the groups. Teachers need a management strategy which helps them understand that the classroom is under control even if they can't supervise all the student behaviors directly. In the classrooms we studied, norms and roles helped to solve the problem of permitting teachers to let go while maintaining control of the classroom.

Moreover, it is not enough to tell teachers that they ought to "let go." They need to understand about delegating authority; they are not giving up control but are monitoring the outcomes through worksheets and controlling the classroom through the cooperative norms and the use of roles. If teachers understand the underlying sociology of the management system, they are more successful in delegating authority and less likely to use direct supervision (Lotan, 1985).

Still another problem that requires attention in classrooms using these work arrangements is the problem of status. If students are working in small groups, some students will be much more active than others. Cohen (1984) has characterized this unwanted domination as a status problem and has documented status organizing processes in classrooms using an early version of this instructional approach. There is evidence that in 1982-83, the status problem has been weakened by the application of strategies for treating this difficulty (Cohen, Lotan, and Catanzarite, in press).

CONCLUSION

Selection of a metaphor of teacher as supervisor leads us to the application of organizational theory to the classroom level. Using organizational sociology, we have been able to develop and test conditionalized propositions that related the type of differentiation in the technology, the nature of the teacher's supervision, and work arrangements among the students to gains in achievement at the classroom level. These propositions provide practical insights for instruction, insights that run counter to current trends in classroom practices.

Theories, like metaphors, are abstract; they select out particular views of phenomena. In doing so, they necessarily omit many other "realities" of a setting such as the classroom. Many investigators are greatly troubled by what is omitted and prefer a more holistic approach. Yet, such abstractions are the very essence of the process of systematic social science. By selecting out certain aspects of the buzzing reality that is the classroom, we are enabled to develop hypotheses and to test these hypotheses. The results are sufficiently robust to conclude that organizational sociology is a strong potential contributor to the improvement of classroom practice.

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Given uncertainty from the workers' point of view,

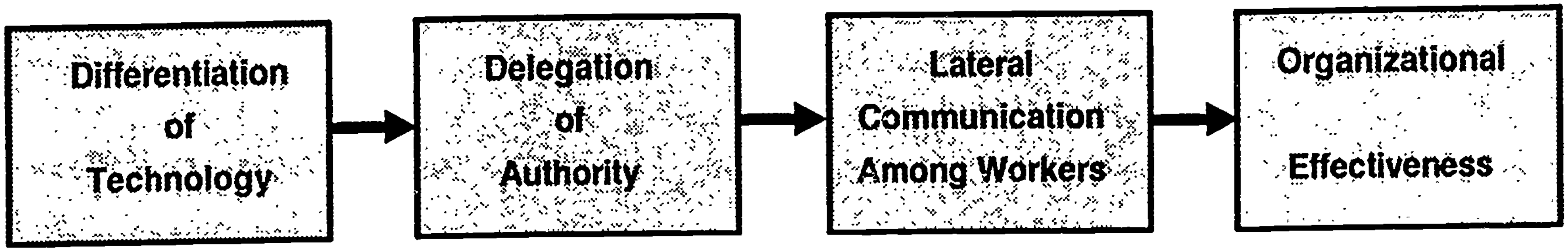

Figure 1

Relationship of Differentiation, Delegation of Authority, and Lateral Communication to Organizational Effectiveness

Table 1

Descriptive Statistics for Variables in Path Model

1982-83

Variable	Mean	SD	N classrooms
Ratio # LC's/Students[1]	0.22	0.03	15
Teacher Facilitates[2]	11.06	3.84	15
% Talk/Work Together[4]	31.43	6.80	15
% Students Work Alone	21.04	7.63	15
Gainscores[6] Concepts/Applications	15.48	11.28	11
Gainscores Computation	26.62	12.24	11

1984-85

Variable	Mean	SD	N classrooms
Ratio # LC's/Students	0.23	0.04	12
Direct Supervision[3]	35.24	13.97	12
TC Talk/Work Together[5]	7.72	2.06	12
% Students Work Alone	9.38	0.16	12
Gainscores Concepts/Applications	40.82	33.23	12
Gainscores Computation	74.39	65.29	12

1. Average of ratio of number of learning centers to number of students in the classroom.
2. Average rate of teacher facilitation per 10 minute observation period.
3. Total of average rate of the following teacher behaviors per 10 minute observation while children are at learning centers: teacher facilitates, instructs, questions and disciplines.
4. Average percentage of students talking and working together in the classroom.
5. Mean of frequency with which set of target children within each classroom were observed talking about the task and working together.
6. 1982-83 gainscores are in national percentiles; 1984-85 gainscores are in standardized scale scores.

Table 2

Intercorrelation of Indicators of Differentiation, Direct Supervision, Student Communication, and Achievement: 1982-83

	Ratio[1] # LC's/Students	Teacher Facilitates[2]	% Talk/Work Together[3]	% Students Work Alone	Gainscores Concepts / Applications
Ratio[1] # LC's/Students	1.00				
Teacher Facilitates[2]	-.50* (N=15)				
% Talk/Work Together[3]	.13 (N=15)	-.43* (N=15)			
% Students Work Alone	.00 (N=15)	.05 (N=15)	-.64** (N=15)		
Gainscores Concepts / Applications	.44 (N=11)	-.48* (N=15)	.72** (N=15)	-.10 (N=11)	
Gainscores Computation	.23 (N=11)	-.18 (N=11)	.61* (N=11)	-.22 (N=11)	.76** (N=11)

* p<.05
** p<.01

1 Average of ratio of number of learning centers to numbers of students in the classroom.
2 Average rate of teacher facilitation per 10 minute observation period.
3 Average percentage of students talking and working together in the classroom.

Table 3

Intercorrelation of Indicators of Differentiation, Direct Supervision, Student Communication, and Achievement: 1984-85

(N= 12)

	Ratio # LC's/Students [1]	Direct Supervision [2]	TC Talk/Work Together [3]	% Students Work Alone	Gainscores Concepts / Applications
Ratio # LC's/Students [1]	1.00				
Direct Supervision [2]	-.55*				
TC Talk/Work Together [3]	.44	-.49			
% Students Work Alone	-.15	-.22	-.55*		
Gainscores Concepts / Applications	.12	-.75**	.52*	.01	
Gainscores Computation	.14	-.58*	.24	.41	.71**

* $p<.05$
** $p<.01$

1 Average of ratio of number of learning centers to number of students in the classroom.

2 Total of average of the following teacher behaviors per 10 minute observation while children are at learning centers: teacher facilitates, instructs, questions, and disciplines.

3 Mean of frequency with which set of target children within each classroom were observed talking about the task and working together.

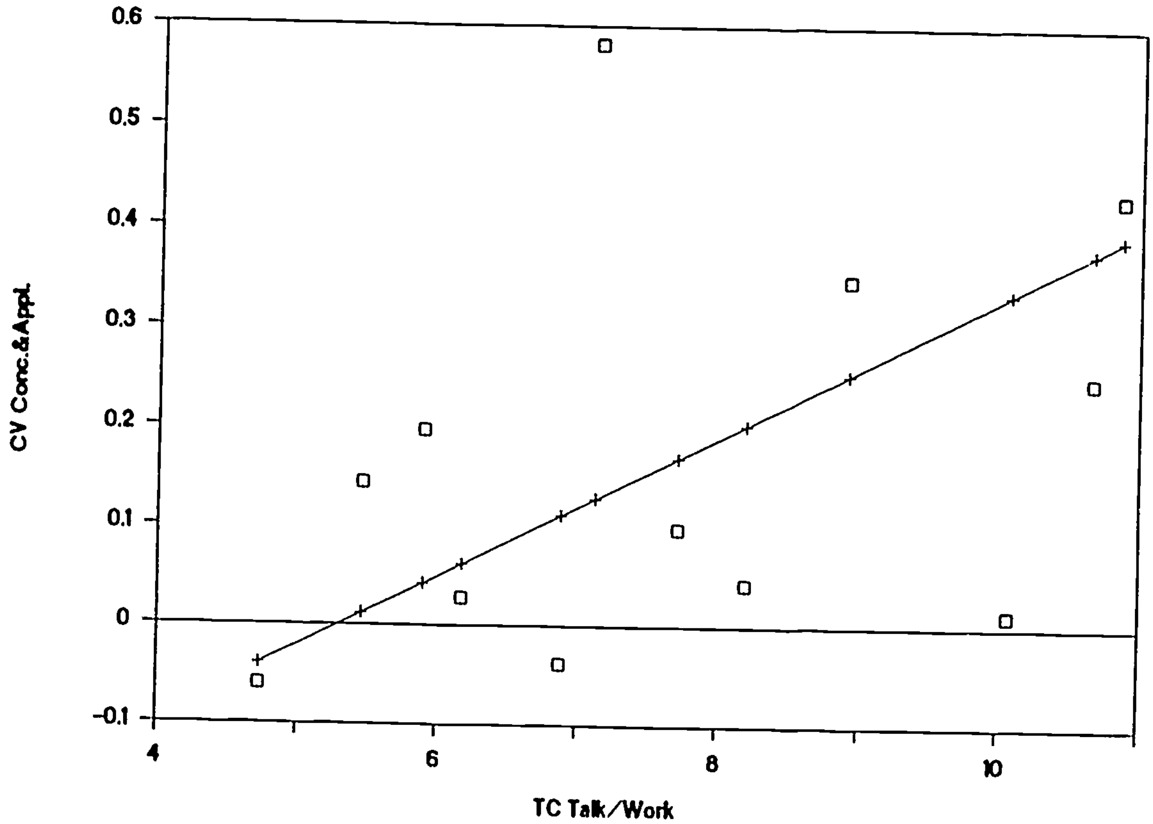

Figure 2

Scatterplot of average rate of target child talking and working together and average difference of coefficients of variation of scores on the concepts and application subscale, by classroom. — — 1984 – 85.

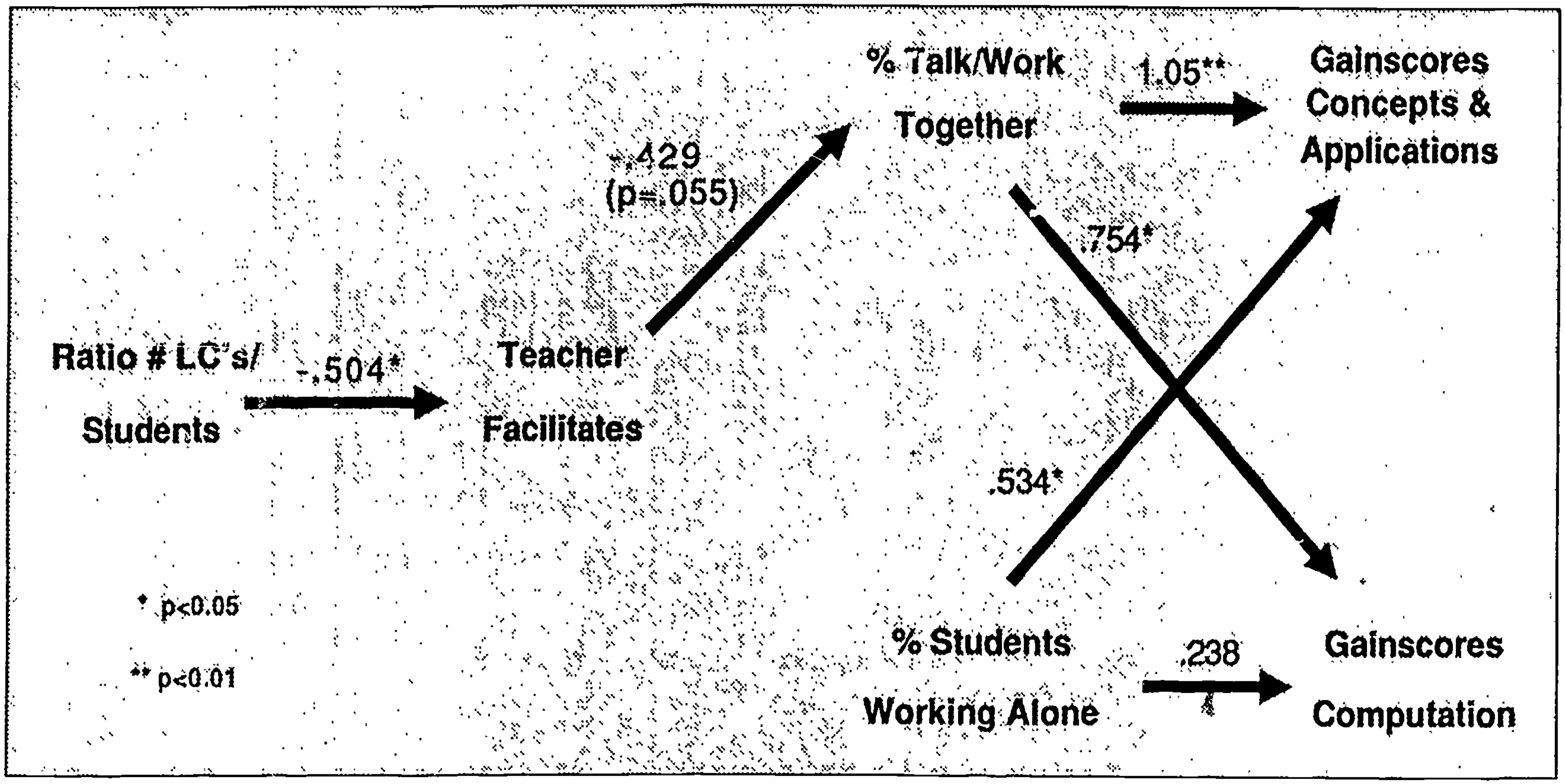

Figure 3

Path Model of Antecedents of Learning Gains: 1982-83

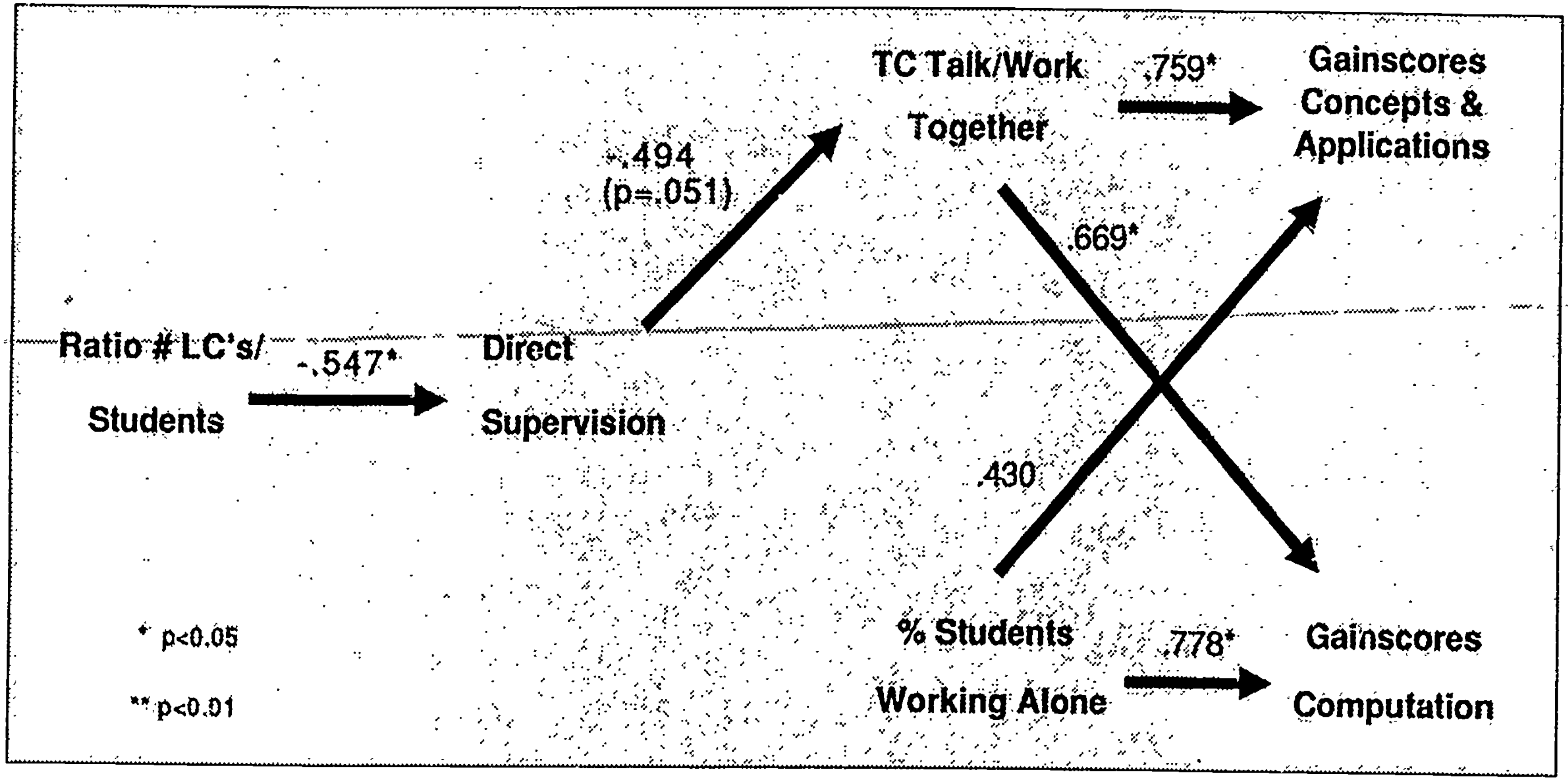

Figure 4

Path Model of Antecedents of Learning Gains: 1984-85