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ABSTRACT

The hypothesis that when true group tasks feature ill-structured problems, interaction will predict learning that involves higher-order thinking skills was tested with middle school students with a strategy called complex instruction. Complex instruction is designed for heterogeneous classrooms in which teaching objectives are conceptual and stress higher-order thinking. Students use each other as resources in cooperative groups. The sample used in analysis of predictors of direct supervision and interaction consisted of 42 middle school classrooms in social studies, human biology, and mathematics. The analysis of achievement and interaction is based on 22 social studies classrooms. Few, if any, groups were larger than five students. Observations confirm a positive, rather than negative, relationship between the size of the learning group and the percentage of students talking and learning together in these relatively small groups. It was demonstrated that given true group tasks and problems with ill-structured solutions, there is a strong and significant relationship between interaction and learning. Direct supervision is counterproductive when groups are in operation. Three tables present study findings. (Contains 12 references.) (SLD)

TALKING AND WORKING TOGETHER:
CONDITIONS FOR LEARNING IN COMPLEX INSTRUCTION

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Talking and Working Together:
Conditions for Learning in Complex Instruction

Cooperative learning is widely used in classrooms for distinctly different purposes. While some developers, researchers and practitioners see this technique as a way to accomplish goals of routine learning such as the application of algorithms in mathematics, others see small groups as an opportunity for students to construct their own knowledge in a way that develops conceptual learning and higher order thinking skills. Noddings (1989) sees this latter school of thought as originating in the work of Dewey and the social constructivism of Vygotsky(1978). Many math and science educators involved in current curriculum reforms belong to the "constructivist" school of thought in the application of cooperative learning to their disciplines ; these educators and researchers assume that conceptual learning cannot be achieved without the creation of suitable discourse or conversation within the small groups or without a process of discovery.

We would argue that interaction among the members of a cooperative small groups is indeed central to conceptual learning. However, there are some key sociological conditions that must be met before the cognitive benefits of interaction can be realized. In this paper we will test the hypothesis that when there are true group tasks that feature ill-structured problems, interaction will predict learning that involves higher order thinking skills. Moreover we would only expect to see this relationship when students have been adequately trained to interact cooperatively.

In a classroom, the stage must be set for interaction to take place in groups. Unless the teacher delegates authority to groups while holding them accountable for performance, one may see little on-task interaction within the groups. Even more basic to the fostering of interaction is the division of students into sufficiently small groups so that everyone has potential "air time" for expressing their ideas.

After showing how these propositions may be derived from sociological theory and past classroom research, we will put them to a test with observational data from middle school classrooms, all of which were using a strategy called complex instruction. Complex instruction is designed for heterogeneous classrooms where the teaching objectives are conceptual and stress higher order thinking. Students use each other as resources in cooperative groups, working on demanding, open-ended tasks requiring a wide range of intellectual abilities and skills.

Theoretical Framework

The hypotheses in this research are derived from a combination of organizational theory and social psychology. They also stem from empirical research that has been carried out on cooperative learning in classrooms. These particular hypotheses have been tested previously on elementary school data on complex instruction. We test the generalizability of these propositions to a different age group, school setting, and different curriculum subjects.

Interaction and learning in small groups

A number of research studies have correlated observed interaction within cooperative groups and achievement, holding constant prior achievement. However, this literature presents a most interesting inconsistency. Webb(1983,1991) showed that in a set of studies of mathematics classes, the simple frequency of interaction did not predict achievement. Most of these studies were conducted in mathematics classes where students were given problems to solve and were told to work together as a group, helping each other, and asking the teacher for help only when no one in the group could assist. She argued that only certain types of interaction -- giving and receiving elaborated explanation, were critical for learning.

In contrast, research on complex instruction at the elementary level has consistently documented the positive relationship between frequency of task-related interaction and gains on standardized and content-referenced tests at the individual as well as at the classroom level(Cohen, 1984; Cohen, Lotan & Leechor, 1989; Leechor, 1988). What differences between these two bodies of studies could account for the differential effectiveness of simple interaction? The first difference lies in the working relationships between the group members. In the case of the group assignments in mathematics, the tasks could have been carried out by individuals. They were not inherently group tasks. A group task is a task that requires resources (information, knowledge, heuristic problem-solving strategies, materials and skills) that no single individual possesses so that no single individual is likely to solve the problem or accomplish the task objectives without at least some input from others(Cohen B. & Arechavala-Vargas, 1987). The tasks used in complex instruction fit this definition of a group task. When working on a group task, members are interdependent in a reciprocal fashion. In other words, each actor must exchange resources with others before the task can be completed. This contrasts with many routine tasks used in cooperative learning where achievement depends on the stronger students helping the weaker students. This arrangement is also interdependent, but the interdependence is sequential as opposed to reciprocal e.g. one student's performance is dependent upon another's, but the reverse is not true.

In the case of complex instruction, reciprocal interdependence is also produced by the system of classroom management in which each student is responsible for helping to insure the success of all members. Each student has a role that has to do with the functioning of the group. Moreover, the students experience a week of skillbuilding activities in which they internalize norms of mutual assistance. Lastly, specific steps are taken to prevent the better students from doing all the helping and weaker students from accepting all of the help (Cohen, B., & Cohen, E.G., 1991). In the studies reviewed by

Webb, there was no such system of classroom management nor was there any special training for cooperative relationships.

The second important difference lies in the nature of the work assigned to the groups. Computational or algorithmic mathematics assignments typically have a right answer that can be reached in well-structured ways while open-ended and discovery tasks such as those used in complex instruction do not have one right answer and are ill-structured problems; they are non-routine problems for which there are no standard recipes or procedures. Under the conditions of a true group task and an ill-structured problem, interaction is vital to productivity(Cohen & Cohen, 1991). Because group members need each other to achieve the best possible product, they must interact with one another in order to achieve their potential. There are at least two ways in which classroom groups can use each other in the course of problem-solving: (1) Those students who do not read or compute well will need to have access to the resources of students with better academic skills; (2) Unless the group members exchange ideas and information, they are unlikely to come up with creative solutions to their assignment or to discover underlying principles. In the case of a classroom setting, productivity is often defined in terms of achievement gains. This conditional relationship between interaction and productivity may be stated as a more general proposition:

> Given an ill-structured problem and a group task, productivity will depend upon interaction.

More specifically: given a problem with no one right answer and a learning task that will require all students to exchange resources, achievement gains will depend upon the proportion of students who are talking and working together.

Delegation of authority

If interaction is critical for achievement, then the job of the teacher is to foster and optimize this interaction. Obviously, when students are working independently in small groups, the teacher's role changes. She or he cannot be everywhere at once telling people what to do; whenever the teacher tries to tell the class something directly, the interaction in the small groups comes to an abrupt halt. Within small groups, the self-directed nature of student talk tends to disappear when the teacher arrives (Harwood, 1989).

The extent to which the teacher applies direct supervision (the obverse of delegation of authority) will diminish the possibilities and opportunities of students communicating with each other. If the teacher, as an authority figure, takes responsibility for their task engagement, students will not assume responsibility for solving problems related to the task. In two data sets, based on classrooms using complex instruction, Cohen, Lotan, & Leechor (1989) found that the rate at which the teacher used forms of direct instruction when students were working in small groups was negatively related to talking and working together among the students. This research provides support for a general sociological principle formulated by Perrow

(1967). Once technology has become more uncertain, two necessary changes should be made in order to maintain or increase organizational productivity: delegation of authority to the workers; and more lateral communication among the workers. In educational terms, this means that when cooperative learning tasks are non-routine, problem-solving or discovery tasks, it is necessary for the teachers to avoid direct supervision and to foster talking and working together within the small groups.

This discussion leads to the second hypothesis:

> Given uncertain group tasks, the rate of direct supervision by the teacher will be negatively related to the proportion of students talking and working together on task.

Differentiation of the technology

The management of cooperative learning requires the teacher to deal with instruction that has become quite complex; instead of the whole class working on the same task, there may be as many as six or seven groups working at their own pace, or in the case of complex instruction each group is working on a different task. The sociologist refers to the latter pattern of work as a highly differentiated technology.

What do teachers do when faced with such a complex mode of instruction? 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 workers are facing tasks that are relatively certain. Comstock and Scott (1977) summarized this argument:" 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." Under conditions of uncertainty, it therefore follows, differentiation will be positively associated with delegation of authority.

In classroom terms, when there are multiple groups each working on different problems with ill-structured solutions, we have a situation that is both highly differentiated and uncertain. In actual practice, the most efficient and productive response to this challenge is not always implemented. Teachers actually vary in how many small groups they employ. They sometimes try to simplify the technology by cutting down on the number of groups so that they can use direct supervision. They may also simplify the situation so that all groups are carrying out the same task. It is then much easier to make sure that each group is solving the problem in a standardized fashion. Even if they try neither of these simplifying strategies, rather than delegating authority they may try to race from group to group to make sure that each task is being done properly and in the manner that the teachers prefer. The sheer impracticality of this latter solution when six groups are carrying out very different tasks pushes teachers toward delegation of authority. At the elementary school level, we found in two data sets taken from classrooms using complex instruction that the larger the number of groups that a teacher is trying to manage, the lower the probability that she will use direct instruction and direct supervision in which she exerts detailed control over how tasks are executed (Cohen, Lotan, & Leechor, 1989).

In the case of the middle school data, there was variation in how many different activities were in simultaneous operation. One classroom with six groups might have six different activities while another might only have three different activities. This leads to the third hypothesis:

> Given uncertain group tasks, the number of different activities in simultaneous operation in a classroom will be negatively related to the use of direct supervision.

A final proposition concerns the effect of the size of groups. When there are fewer, larger groups in a classroom, the opportunities for individuals to talk are limited by the "air time" available for a given member of the group. Obviously, there is not as much air time for students in larger groups as in smaller groups.

The fourth and final hypothesis follows:

> The size of the small groups will be directly related to the percentage of students observed talking and working together in the classroom.

From an educational perspective, the importance of these factors that affect the amount of interaction in groups, such as delegation of authority and differentiation of the technology, lies in the relationship of interaction to learning outcomes. Teachers who have too few groups or who try to use direct supervision when students are working cooperatively, unwittingly sabotage the attainment of their objectives. By inhibiting the process of talking and working together, they prevent the students from developing a good grasp of concepts or from discovering things for themselves.

Design of the Study

Although all the middle school classrooms in this study used complex instruction, there were important classroom differences in the number of activities, in the size of small groups, in the extent to which teachers used direct supervision when students were working in groups, and in the proportion of students talking and working together when groups were in operation. We test the hypotheses by correlating these classroom statistics with each other and with the average classroom gains in a test of higher order thinking skills.

All the teachers were using specially prepared curricula in social studies/language arts, mathematics, and human biology that provided activity cards for each group. The tasks, in each case, fit our definition of group tasks. Moreover, the tasks were open-ended and uncertain, thereby fulfilling our criteria for problems with ill-structured solutions. For example, students in social studies were asked to design a Crusader castle they could defend or create a role play on how the Crusader Handbook was used to recruit ,easants for the Crusades. Students in mathematics read a story about two tug-of-war matches involving giant frogs, athletic grandmas, and a frisky kangaroo. In the story the students find that an even tug-of-war is five grandmas of equal strength pulling against four giant frogs, also of equal strength. Another even match results when the kangaroo pulls against two grandmas and a giant frog. The group's task is threefold: (a) to use characters from the story to create a tricky tug-of-war match that would not come out even (b) to provide a written account of two different ways to verify mathematically which side would win the tug-of-war it had created, and (c) to make a poster that presents its tug-of-war problem for others to solve.

All the teachers received the same type of staff development and classroom follow-up. They attended a two week workshop on complex instruction that was followed up by systematic classroom observations of their classrooms. After three observations on a given classroom, staff developers provided feedback to the teachers in which they discussed the results of observations, using a bar graph presentation. Teachers received between one and three such feedback visits.

The students were prepared for cooperative learning with a set of skillbuilding experiences. Some of these skillbuilders were specifically directed to improving the character of group discussion by training the students to present their rationales and ideas in a more articulate fashion.

All the variables with the exception of learning outcomes were measured with systematic observations. Achievement data for this study only include tests on the social studies units.

Correlations and multiple regressions were used to test the hypotheses at the classroom level. The hypothesis concerning interaction and achievement outcomes was tested only on the social studies classrooms where we had achievement measures. The other hypotheses concerning the predictors of direct supervision and interaction were tested on the larger sample of classrooms in the three subject matters.

Setting and Sample

During the 1991/92 school year, we worked with five middle schools from five districts in the larger Bay Area. The student population at all of these schools was racially and ethnically mixed, a fair representation of California's present student demographics. All of these schools had made a commitment to untrack in all subject matters. They had also integrated social studies and language arts in their 7th grades and had assigned two or three period sessions to a "core" subject.

For each participating teacher, we selected (where possible) two kinds of classrooms for closer follow-up. Based upon the students' existing reading scores on standardized tests, we constructed a profile to reflect the academic range in the classroom. Although the schools considered themselves to be detracked, we found that some classrooms had a wider range than others, i.e., were more heterogeneous than others. We then selected (where possible) one heterogeneous and one more homogeneous (high or low) classroom for each teacher to be included in our sample.

The sample used in the analyses of the predictors of direct supervision and interaction consisted of 42 classrooms in all three subject matters. The analysis of achievement and interaction is based on 22 social studies classrooms.

Measurement

Observation data

We were able to collect complete sets of observation data in 42 classrooms across the three subject matters (social studies, HumBio and mathematics). We used the teacher observation instrument to record the rate of teacher facilitating, instructing, and disciplining -- our indicators of direct supervision. Facilitation includes telling students how to get through the task or procedural questions such as "Did you read the resource cards?", "Does the group know what you are supposed to do?" There were a total of 246 such teacher observations. For purposes of this study, we counted only teacher behaviors during the time that students were at the learning stations, when delegation of authority is required.

Inter-scorer reliability was measured by the percentage agreement based on a comparison of the scoring by the rater and the criterion scorer. Reliability on this observation instrument was 93.64%. We standardized the rates of teacher talk by the number of minutes for each observation and averaged all the observations of a particular teacher to construct an index of direct supervision. The index of direct supervision was the average rate of teacher talk in the total of the following categories: Teacher Facilitates, Teacher Instructs, and Teacher Disciplines. To check whether there was greater variation among the teachers in a sample then there was among the observations of a particular teacher, we performed ANOVA's for the combined total of these three categories each observation. The ANOVA showed significant teacher effects for this index ($F = 1.623$; $P = .013$).

We used the whole class instrument to obtain measures of differentiation, number of students per learning station, and the proportions of students talking and working together. This instrument consists of a grid representing grouping and activity patterns of students. The observers counted the number of students who were engaged in various activities such as talking, manipulating the materials, looking and listening or disengaged at the learning stations and sometimes away from the centers (in transition/ on business, wandering, playing). The number of different learning stations and the number of different kinds of curricular materials used at the centers were also recorded.

This instrument is like a snapshot of all the students and the teacher at a given time. We have 502 such observations for the classrooms of this study always taken when the students were working at the learning stations -- after the initial orientation to the lesson and just before the final wrap-up. Inter-scorer reliability on this instrument was 94.42%.

The relevant statistics for the purposes of this analysis were constructed in the following manner: The proportion of students talking and working together is based on the average percentage of students over a set of observations for a given classroom checked off in the "Talking" or "Talking and Manipulating Materials" categories. Students who were in engaged in non-task talk were not included. The measure of differentiation is the average number of different activities in simultaneous operation, as noted in the whole class instrument. The number of students per groups was calculated as a grand mean of the average number of students per learning station for each observation of a given classroom. As with the teacher observation instrument, we performed ANOVA's on the variables of interest before aggregating across observations. Results were as follows: Percentage talking and working together (F = 2.605; P = .000; Number of different activities (F - 10.617; P = .000); Students per learning station (F = 9.347; P = .000).

Achievement tests in social studies

The multiple choice tests for the 7th and 8th grade in social studies had two major sections: factual information and higher order thinking. When designing test items, we carefully consulted the state-approved textbooks and tests published to accompany the textbooks because we planned to administer the tests in both CI classrooms and comparison classrooms where

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students didn't have access to the CI curricula. We had decided that each test item had to reflect content presented in both conditions. We wanted all students taking the test, regardless of their exposure to CI curricula to have a reasonable chance of answering the questions correctly. For the factual information items, we used as many questions from the textbook's published tests as possible. We wrote the higher-order thinking questions. The same test form was used for pre-and post-tests.

The tests for the 8th grade included 40 items: 30 factual and 10 higher-order thinking items. It covered materials on the following topics: Manifest Destiny, the Civil War, and the Rise of the Industrial Era. All these topics are part of the California State Framework and all are covered in the textbook. Seven teachers reviewed a prototype of the 8th grade test, and based on their comments and critique we revised the test.

The 7th grade test had 50 items, 33 factual and 17 higher-order thinking items. It covered materials on the following topics: Feudal Japan, the Crusades, the Maya, and the Reformation. All topics are part of the California Framework, and all are covered in the textbook most frequently used in California schools.

All the students present in the selected classes took the whole test early and late in the school year. For the purposes of the analyses reported in this paper, we constructed a gain score for each student who took the pre- and the post test and calculated the average gain score per classroom based on these individual gain scores.

Results

Table 1 shows the means and standard variations for the variables used to test our hypotheses. As indicated, the average number of different activities occurring at one time was 4.11. The analysis of variance tests indicated that this average varied significantly by class ($F = 10.62$, $p < 0.001$) as well as subject ($F = 108.99$, $p < 0.001$).

(Table 1 about here)

Direct supervision on the part of the teacher was relatively high. Teachers averaged 13.39 remarks during 10 minutes of observation. This total was boosted by some teacher who made numerous short remarks. The average number of students per group was 3.75. As evidenced by the range of this variable, none of the groups were very large. In fact, many of the groups must have had three or less students.

The percentage of students observed to be talking and working together was, on average, 36.45%. There was a tremendous amount of variation in this measure among the classrooms we observed ($SD = 8.80$).

Lastly, the classrooms tested gained an average of 12.14% of the total number of items between the pre and post test. This was computed by subtracting each individual's total pretest score from their total posttest score. The standard deviation for this mean was 7.50, indicating considerable variability in achievement as well. While not directly relevant to the analysis described in this paper, it is of interest to note that these classrooms did significantly better than comparison classrooms in which the same topics were covered without Complex Instruction.

Testing the Hypotheses

As can be seen in Table 2, the four hypothesized relationships discussed earlier all show statistically significant correlation coefficients. However, as will be discussed later, one is not in the direction predicted.

(Table 2 about here)

First, the average amount of interaction per classroom as measured by the percentage of students talking and working together is positively correlated with average achievement gains per classroom ($r = 0.50$, $p < 0.01$). Those classrooms where students were more actively engaged in talking about the task, gained more than those classrooms with smaller percentages of students talking and working together. The second hypothesis regarding the relationship between the measures of direct supervision and interaction is supported as well: There is a statistically significant negative correlation between the average rate of direct supervision and percentage of students talking and working together ($r = -0.52$, $p < 0.001$). In other words, those teachers who tended to engage in direct instruction while students were in groups had fewer students talking ad working together than those teachers who interfered with the groups less. Third, the number of different activities in simultaneous operation is negatively related to the use of direct supervision ($r = -0.40$, $p < 0.01$). Teachers who were working with a smaller number of activities were more likely to engage in direct supervision than teachers who used as many as six groups each with different activities.

Lastly, the size of the small groups is directly related to the percentage of students observed talking and working together ($r = 0.40$, $p < 0.01$). However, it should be noted that this last correlation is in the opposite direction of that predicted. Instead of finding that larger groups cut down on the number of students interacting, the results show that the greater the size of the group, the larger the proportion of students interacting.

There are other interesting correlations not previously hypothesized. For example, the smaller the size of the groups, the higher was the rate of direct supervision ($r = -0.26$, $p < 0.05$). Also, the amount of interaction was positively related to the number of different activities ($r = -0.47$, $p < 0.01$). Finally, when there were different activities, there were somewhat larger groups ($r = -0.28$, $p < 0.05$).

The Path Model

The path model depicting the hypothesized relationships between status, interaction, and learning is presented in Figure 1. Note that in the path analysis, we were not attempting to model a phenomenon. Rather, we were testing a specific theoretically driven argument. Thus, the detailed causal model in Figure 1 presents the particular indicators of basic concepts that are relevant to the data set. If we were modeling the phenomenon, we would include some of the additional relationships just noted in the matrix of correlations.

(Figure 1 about here)

Table 3 presents the separate regression analyses used to estimate the path coefficients for the model. Included in the table are the standardized coefficients, the standard error and the value of R^2.

(Table 3 about here)

The quantities reported over the arrows in Figure 1 are the path coefficients or standardized regression coefficients taken from the equations reported in table 3.

As expected, teachers in classrooms with greater differentiation had lower rates of direct supervision ($r = 0.50$, $p < 0.01$). In addition, both direct supervision and the number of students per group are independent predictors of the percentage of students talking and working together; a regression of the percentage of students talking and working together on both direct supervision and number of students per group indicates that both variables are significant predictors. The path model shows a statistically significant negative coefficient between direct supervision and student interaction($r = -0.44$, $p < 0.01$), while there is a significantly positive coefficient--the opposite of what we expected--between the number of students per group and interaction ($r = 0.29$, $p < 0.05$). In turn, interaction is a positive predictor of learning gains in social studies ($r = 0.50$, $p < 0.01$).

Discussion and Implications

There was general support in the data for all but one of our hypotheses. As we have indicated, there was a positive, rather than negative relationship between the size of the group and the percentage of students talking and working together. That is, we found that the larger the average size of the groups, the greater the percentage of students talking and working together. This is explainable when we consider the range of the size of the groups in our classrooms. Few, if any, groups were larger than five students. In fact, often groups consisted of three or fewer students. Thus, air time was not the critical issue--a lack of intellectual resources were. These activities are designed to be challenging, multiple ability, and interdependent--we suspect that groups of two or three did not have the resources within the group to complete the activity. As a result, students in these groups may have either quietly or disruptively given up.

As reported, the number of different activities implemented simultaneously varied by subject and by class, thus producing the variability in differentiation. The math units, for example, did not always provide a variety of activities around the same 'big idea'. Rather, the same activity was given to each group with only some slight variation, if any, in the product required. In some classrooms, in an effort to simplify the implementation, some teachers reduced the number of different activities occurring simultaneously. The consequences for student learning are apparent in our research: the fewer the number of activities, the greater the level of direct instruction, and the lower the interaction.

As we have seen, the level of direct instruction is not the only predictor of interaction--the size of the group is important as well. What then, is the optimal size of the groups? Considering our results, it would appear there is both an upper and lower limit to the size of the groups. On the one hand, groups of only two or three may be appropriate for a somewhat simpler task such as completing a worksheet, studying for a spelling test, or performing a scientific lab, but are not large enough for the stimulating, challenging activities in Complex Instruction curricula. On the other hand, groups larger than five do not provide all students with the chance to contribute as individuals compete for scarce time to talk and work together. Additionally, students in such large groups are unable to make eye contact with all members of the group or are physically isolated because of the size of the table necessary to hold all members.

Organizational theory has powerful and practical implications for the use of cooperative learning in classrooms. Those curriculum developers and educators who hope to hear students in groups constructing their own knowledge as they solve open-ended problems in mathematics or experiment and discover should be aware of the implications of this work. In the first place, interaction in the groups is unlikely to be a direct precursor of learning unless they have created true group tasks and uncertain problems. In creating curricula, we have found that tasks which are open-ended and contain a healthy level of uncertainty facilitate such student talk. In addition, the tasks must also be conceptually challenging--vocabulary words for a unit of the Maya civilization or the structures of the eye may be best learned via a lecture or individual worksheet. Group tasks, however, should pose or ask students to pose provocative and challenging problems which require four or five minds to collectively solve the problem and create a product.

Secondly, they need to set the stage for the desired interaction to take place. Teachers have to be retrained to delegate authority to groups and to avoid direct instruction when groups are in operation. They would do well to create different activities for different groups so as to push the teacher to avoid direct instruction.

This work also has direct implications for teachers. Teachers can increase the amount of student-to-student interaction by minimizing the amount of direct supervision when students are working in their groups. When a teacher facilitates, disciplines, or provides direct instruction, it has the effect of shutting down the student talk. While, it is sometimes necessary to intervene with the work of a group, high levels of direct instruction will lead to low levels of interaction among students.

However, lowering one's level of direct instruction is not necessarily easy or natural. Thus, we suggest increasing the number of *different* activities simultaneously being implemented. If, for example, each group in the class is working on a different activity related to the digestive system, the teacher will be unable to interrupt the groups with directions about how far they should be on the activity and what they should do next. Rather, as teachers delegate authority to the groups, students become responsible for monitoring themselves and completing the task successfully.

Conclusion

We have been able to demonstrate the generalizability of our propositions from the elementary to the middle school. In both settings, it has been shown that given true group tasks and problems with ill-structured solutions, there is a strong and significant relationship between interaction and learning. It is also the case that direct supervision is counterproductive when groups are in operation in that interaction and therefore learning outcomes are weakened. Finally, the level of differentiation of the technology will push teachers to use less direct supervision. We have shown these propositions to hold despite the major differences in the age of the student, the organization of the school, and the subject matter of the curricular tasks.

Table 1. Descriptive Statistics for Variables in the Path Model

Variable	Mean	*SD*	Min./Max.	Number of Classrooms
Number of Different Activities[a]	4.11	1.93	1.00/8.00	42
Teacher Direct Supervision[b]	13.39	3.70	6.92/21.75	42
Number of students per group[c]	3.75	0.31	3.07/4.50	42
% talk/work together[d]	36.45	8.80	17.13/56.48	42
Gain scores[e]	12.14	7.50	-4.80/29.80	22

[a] Average of the number of different activities implemented simultaneously.
[b] Total of the average rate of the following behaviors of teacher per 10-minute observation while children were at the learning centers: teacher facilitates, instructs, and disciplines.
[c] Average of the ratio of the number of students to the number of learning centers
the learning centers: teacher facilitates, instructs, and disciplines.
[d] Average percentage of students talking and working together in the classroom.
[e] Percentage gained on social studies test

Table 2. Intercorrelation of Indicators of Differentiation. Size of the Groups, Direct Supervision, and Interaction (N=42)

	Number of Different Activities	**Teacher Direct Supervision**	**Number of students per group**	**% talk/work together**
Number of Different Activities[a]	1.00			
Teacher Direct Supervision[b]	-0.40**	1.00		
Number of students per group[c]	0.28*	-0.26*	1.00	
% talk/work together[d]	0.47**	-0.52***	0.40**	1.00

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Table 3. Standardized Regression Coefficients and Standard Errors (in parentheses) for equations in the path models (N=42)

Dependent Variables/ Predictors	Teacher Direct Supervision	% talk/work together
Number of Different Activities	-0.40** (0.28)	
Teacher Direct Supervision		-0.44** (0.32)
Number of students per group		0.29* (3.80)
R^2	0.16	0.35

* $p < 0.05$
** $p < 0.01$

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