The purpose of this study was to investigate the effect of the levels of group cooperation on students' achievement during a series of physical science laboratory activities. Six intact seventh grade physical science classes taught by two teachers, with each teacher instructing three classes, were selected from two middle schools. For each teacher, one of the classes was taught with a traditional approach (no cooperative goal structure). The other two classes were assigned to a cooperative goal structure (role assignment and non-role assignment). For the role-assignment class, each student was assigned a specific role, but students in both traditional and non-role assignment classes were not assigned roles.

The Classroom Observation Instrument in Science Laboratory Activity (COISLA), which includes investigative skills (i.e., managing, manipulating, observing, reading, writing, and reporting); social skills (i.e., discussing, encouraging) and non-learning behaviors (i.e., waiting, off-task), was used to measure the levels of group cooperation. The grades on lab reports and lab quizzes of students who were taught
by the same teacher were compared to assess the effects of the different learning conditions.

No significant differences on the students' final achievement were found with respect to the three instructional approaches followed by each teacher. The teacher effect was more significant than either instructional approach on managing, manipulating, observing, reading, and writing behaviors. No significant teacher effect was found for the other behaviors. Only one treatment effect was significant, writing behavior. Overall, the teacher effect was more influential than instructional approach on students' behaviors. In teacher A's classes, reading behavior predicted 21% of students' achievement. However, no significant correlations existed between the ten collaborative behaviors and students' achievement in teacher B's classes.
The Effect of Levels of Cooperation Within Physical Science Laboratory Groups on Physical Science Achievement

by

Huey-Por Chang

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TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
</tr>
<tr>
<td></td>
<td>Background of the Problem</td>
</tr>
<tr>
<td></td>
<td>Statement of the Problem</td>
</tr>
<tr>
<td></td>
<td>Significance of the Study</td>
</tr>
<tr>
<td></td>
<td>Definition of the Terms</td>
</tr>
<tr>
<td></td>
<td>Research Questions</td>
</tr>
<tr>
<td>II</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Review of Relevant Literature</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
</tr>
<tr>
<td></td>
<td>Cooperative Learning in the Science Classroom</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
</tr>
<tr>
<td></td>
<td>Laboratory Teaching Strategy in Science</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
</tr>
<tr>
<td></td>
<td>Studies with Laboratory and Cooperative Learning</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
</tr>
<tr>
<td></td>
<td>Survey of Observation Instruments Used in Laboratory and/or Cooperative Studies</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
</tr>
<tr>
<td></td>
<td>Critical Criteria for the Development of a Classroom Observation Instrument</td>
</tr>
<tr>
<td></td>
<td>Positive Role Interdependence and Role Assignment</td>
</tr>
<tr>
<td></td>
<td>Social Skills and Investigative Skills</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
</tr>
<tr>
<td></td>
<td>Summary of the Literature Review</td>
</tr>
<tr>
<td>III</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Design and Method</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
</tr>
<tr>
<td></td>
<td>Subjects</td>
</tr>
<tr>
<td></td>
<td>Procedures</td>
</tr>
<tr>
<td></td>
<td>Development of Observation Instrument</td>
</tr>
<tr>
<td></td>
<td>Collaborative Behaviors</td>
</tr>
<tr>
<td></td>
<td>Observation Instrument</td>
</tr>
<tr>
<td></td>
<td>Validity and Reliability of the Observation Instrument</td>
</tr>
<tr>
<td></td>
<td>Classroom Observation</td>
</tr>
<tr>
<td></td>
<td>Practice of Observation</td>
</tr>
<tr>
<td></td>
<td>Data Collection</td>
</tr>
<tr>
<td></td>
<td>Independent Variables</td>
</tr>
<tr>
<td></td>
<td>Dependent Variable</td>
</tr>
<tr>
<td></td>
<td>Hypotheses</td>
</tr>
<tr>
<td></td>
<td>Data Analysis</td>
</tr>
<tr>
<td>IV Analysis of Data</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Introduction</td>
<td>96</td>
</tr>
<tr>
<td>Students' Beginning Achievement</td>
<td>96</td>
</tr>
<tr>
<td>Students' Final achievement</td>
<td>97</td>
</tr>
<tr>
<td>Students' Collaborative Behaviors</td>
<td>102</td>
</tr>
<tr>
<td>The Relationships Between Collaborative</td>
<td>109</td>
</tr>
<tr>
<td>Behaviors and Achievement</td>
<td></td>
</tr>
</tbody>
</table>

| V Discussion and Conclusions           | 116    |
| Introduction                           | 116    |
| Interpretation and Discussion of the Results | 117  |
| Students' Achievement                  | 118    |
| Students' Collaborative Behaviors      | 120    |
| Relationship Between Collaborative Behaviors and Students' Achievement | 127 |
| Limitations of the Study              | 130    |
| Recommendations for Future Research    | 132    |
| Implications for Science Teaching and Science Education Research | 134 |

References | 140
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The basic model of recent research designs on the cooperative learning strategy</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>The basic model for most of the research designs on laboratory teaching strategy</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>Different kinds of laboratory teaching strategies are categorized in two dimensional system</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>Observation sheet for role assignment group</td>
<td>88</td>
</tr>
<tr>
<td>5</td>
<td>Observation sheet for non-role assignment group and traditional group</td>
<td>89</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>Summary of class and group assignment to instructional approaches</td>
<td>81</td>
</tr>
<tr>
<td>2</td>
<td>Group composition, number of students in each instructional approach</td>
<td>82</td>
</tr>
<tr>
<td>3</td>
<td>Descriptive statistics for students' beginning achievement</td>
<td>97</td>
</tr>
<tr>
<td>4</td>
<td>The frequency of students' absences during the formal observation period</td>
<td>98</td>
</tr>
<tr>
<td>5</td>
<td>Descriptive statistics for students' final achievement</td>
<td>99</td>
</tr>
<tr>
<td>6</td>
<td>ANCOVA for students' final achievement for teacher A</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>Unadjusted and adjusted group means of final achievement among three approaches for teacher A</td>
<td>101</td>
</tr>
<tr>
<td>8</td>
<td>ANCOVA for students' final achievement for teacher B</td>
<td>101</td>
</tr>
<tr>
<td>9</td>
<td>Unadjusted and adjusted group means of final achievement among three approaches for teacher B</td>
<td>102</td>
</tr>
<tr>
<td>10</td>
<td>Descriptive statistics for each of ten collaborative behaviors</td>
<td>103</td>
</tr>
<tr>
<td>11</td>
<td>MANOVA for interaction effect on students' collaborative behaviors</td>
<td>105</td>
</tr>
<tr>
<td>12</td>
<td>MANOVA for instructional approach effect on students' collaborative behaviors</td>
<td>105</td>
</tr>
<tr>
<td>13</td>
<td>Univariate analysis of each of the ten collaborative behaviors for instructional approach</td>
<td>106</td>
</tr>
<tr>
<td>14</td>
<td>Multiple range analysis for writing behavior by instructional approach</td>
<td>107</td>
</tr>
</tbody>
</table>
15 MANOVA for teacher effect on students' collaborative behaviors 107
16 Univariate analysis of each of the ten collaborative behaviors for teacher effect 109
17 Correlations between students' achievement and ten collaborative behaviors for teacher A 111
18 Correlations between students' achievement and ten collaborative behaviors for teacher B 114
THE EFFECT OF LEVELS OF COOPERATION WITHIN PHYSICAL SCIENCE LABORATORY GROUPS ON PHYSICAL SCIENCE ACHIEVEMENT

Chapter I

Introduction

Background of the Problem

Laboratory work has long been regarded as an integral and necessary aspect of the learning experience in science courses (Blosser, 1981; Hofstein, Ben-Zvi, & Samuel, 1976; Kyle, Penick, & Shymansky, 1979). Additionally, the use of small groups (two to six persons) in science laboratory work is very common (Seymour & Padberg, 1975); therefore, student group behavior and student-student interactions may have an influence on group performance. Unfortunately, one or two students within a group may tend to dominate while the other students exhibit passive behaviors such as observing or copying. Even though the goal is to involve students equally in laboratory activities, in reality, this is difficult to do. Collette and Chiappetta (1984) and Johnson and Johnson (1987) have suggested that the levels of cooperation within the group (or group cooperation) will be increased if each of the group members is
assigned a specific role. But, data are not available to support this approach.

Teachers often do not know exactly what students are doing or thinking during laboratory sessions. In many cases, teachers feel that they have lost control of instruction. The students often do not know how to do the investigative procedures for the laboratory activity. Also, some students might not know what their group members are doing and they may repeat a procedure which was supposed to be done by only one person. Because the process of the investigation is often not sequentially and effectively organized, it is difficult for the members of the group to reach a consensus. The most difficult part of the laboratory activity for students is to make sense of the activities and to relate them to theoretical concepts (Tamir, 1989). If the cooperation within each group could be increased, the performance of laboratory work might be improved. Therefore, it is important that we find a model of teaching which can facilitate student interaction and student achievement in laboratory activities.

There is considerable evidence indicating that a cooperative goal structure has the most powerful impact in promoting achievement and productivity among the three kinds of goal structures, which include: competitive, individualistic, and cooperative learning conditions (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Okebukola, 1986b). However, differences between assigned experimental conditions and actual classroom practice have not been considered in most studies. In addition, very few of the mediating variables which exist between the general cooperative goal structure and achievement have been identified.
(Johnson et al., 1981; Lyons, 1982; Yager, 1985). In science laboratory activities, students are often arranged to work within a group. So, the science laboratory appears to be an appropriate place to measure student-student interactions within a group. A result of one naturalistic study by Hertz-Lazarowitz, Baird, Webb, and Lazarowitz (1984) indicated that cooperation was the most frequently utilized approach among the five instructional modes, which include lectures, laboratory work, individual work, films and games, and tests. Given that the effectiveness of group work will unavoidably influence learning in the laboratory activity, the levels of cooperation that small groups use to achieve their learning goals needs to be understood in terms of both learning and teaching in science education (Allen & Feldman, 1976; Webb, 1982).

**Statement of the Problem**

The purpose of this study was to investigate the effect of the levels of group cooperation on students' achievement during a series of physical science laboratory activities. The instructional approaches included: cooperative goal structure with assigned roles, cooperative goal structure without assigned roles, and "traditional" (students working in groups without a cooperative goal structure). The relationship between levels of cooperation within the groups and students' achievement was determined and was used to indicate the effect of levels of group cooperation on learning in middle school physical science laboratory activities among the three instructional approaches.
Significance of the Study

Within the research on cooperative learning, almost no studies have been conducted to measure the levels of cooperation within the students' groups. Instead, most of studies were carried out by simply assigning the classrooms to one of the three goal structures, (i.e., cooperative, competitive, and individualistic conditions). The specific interactions between the students were often ignored. Unless the levels of group cooperation are measured, an in depth understanding of the effect of cooperative learning on students' achievement is difficult to discern. Enhancing the effect of laboratory experiences has been an issue in science teaching for a long time. As group cooperation increases, the effectiveness of laboratory teaching may also be increased. Since this study was conducted in a laboratory situation, the results might also clarify the argument concerning the effectiveness of laboratory teaching.

Definition of Terms

Competitive goal structure - individuals' goal achievements are negatively correlated; when one person achieves his or her goal, others with whom he or she is linked fail to achieve their goals.

Cooperative goal structure - individuals' goal achievements are positively correlated; when one person achieves his or her goal, others with whom he or she is cooperatively linked achieve their goals.
Goal structure - specifies the types of interdependence existing among students and specifies the ways in which students will relate to each other in working toward the accomplishment of instructional goals.

Individualistic goal structure - individuals' goal achievements are independent; the goal achievement of one person is unrelated to the goal achievement of others.

Non-role assignment - during the laboratory activities, each member of the group is not assigned a specific role.

Role assignment - during the laboratory, each member of the group is assigned a specific role such as: manager, investigator, coordinator, and recorder.

Traditional group - during the laboratory activities, each student will work in a group without a cooperative goal structure.

Research Questions

This study addressed the following questions:

(1) Is there a significant difference among the three instructional approaches in terms of students' achievement in laboratory activities?

(2) Is there a significant difference in the frequencies of collaborative behaviors among students in the three instructional approaches?
Chapter II

Review of Relevant Literature

Introduction

Since Deutsch (1949) first published his now classic theory on cooperation and competition, numerous studies have been conducted on the relative effects of the cooperative, competitive, and individualistic goal structures on performance. Some studies support cooperative learning (Humphreys, Johnson, & Johnson, 1982; Johnson, 1981; Johnson, Johnson, & Stanne, 1986; Johnson, Skon, & Johnson, 1980; Okebukola, 1985; Okebukola, 1986a; Okebukola, 1986b; Okebukola & Ogguniyi, 1984; Sharan, 1980; Slavin, 1980; Tjosvold, Marino, & Johnson, 1977), while Michaels (1977) contended that competition between individuals was more effective than cooperative and individual goal structures in increasing performance. Sherman (1989) found no significant differences in the pretest and posttest scores between cooperative and competitive conditions in two secondary biology classrooms. Lazarowitz, Hertz, Baird, and Bowlden (1988) found that the cooperative and small-investigative group method did not have a consistent effect on two units of study in 10th grade general biology. Although most studies indicate the dominant effects of cooperative learning, very few studies have assessed whether the assigned goal structures were actually implemented as designed. This is a serious problem in the area of cooperative learning research.
In secondary school science teaching, the laboratory activity is often scheduled to provide students with a hands-on opportunity to learn science. Several students are often assigned to a group in a laboratory activity. Therefore, student-student interactions in a laboratory group should be understood if the effect of the laboratory on science learning is to be assessed. In essence, the effectiveness of applying a cooperative learning strategy to a science laboratory is the primary interest of this investigator. However, very little research has been conducted in this area. Research on cooperative learning has overlooked the students' cooperation in a laboratory class in which the students' levels of cooperation within the group may affect students' achievement. Therefore, the review of research relevant to this investigation consists of five areas: (1) cooperative learning in the science classroom, (2) laboratory teaching strategy in science, (3) studies with laboratory and cooperative learning, (4) survey of observation instruments used in laboratory and/or cooperation studies, (5) critical criteria for the development of a classroom observation instrument.

**Cooperative Learning in the Science Classroom**

Studies which are related to other subject matter domains such as language and social science were not included here. The review of articles in these areas would not help identify and build a theoretical framework, since the learning process in science is different from other subjects when one considers the nature of scientific knowledge, teaching materials and instructional activities.
In most research studies on cooperative learning, classes were frequently assigned to three different patterns according to the purpose of the research. Then, the effects on students' achievement from learning within different goal structures were compared. However, it was not always practical or realistic to assign students to work individually during the process of learning. It was also unusual to ask students to compete with each other without exchanging or sharing thoughts, or understanding in the classroom. Figure 1 indicates a general model for most cooperative learning research. The reader is reminded that Figure 1 should be read from bottom to top. Further, the differences between actual instruction and assigned treatments were very rarely investigated. Additionally, no information on the levels of cooperation within groups was obtained.

Tjosvold et al. (1977) used a 2 (inquiry versus didactic) x 2 (cooperation versus competition) factorial design to investigate the effects of inquiry and didactic teaching when students either cooperate or compete with each other on students': (a) acceptance of the teaching method, (b) approval of the teacher, (c) experience of peer support, and (d) beliefs that they have learned.

The sample was 80 students from the fourth and fifth grades of an elementary school and were predominantly from working and lower middle-class backgrounds. Four intact classes of 80 students were randomly assigned to the four treatment conditions which were cooperative-inquiry, cooperative-didactic, competitive-inquiry, and
Most research indicated the superiority of cooperative learning to the other two kinds of interaction patterns.

Comparing the effects of three kinds of student-student interactions on the students' achievement

Figure 1. The basic model of recent research designs on the cooperative learning strategy
competitive-didactic. The students in the cooperative group and competitive group studied under the climate which fit their goal structures.

The instrument included four self-report items with a three-point scale for each item to collect students' acceptance of the teaching methods, approval of the teacher, peer support, and subjective learning (i.e., students believed they had learned). The lower the score, the more favorable the response.

A lesson on liquid evaporation was adapted from Science for the Seventies (Pennsylvania Department of Education, 1973) because the students had not studied evaporation and were expected to be interested in it. The lesson lasted approximately 55 minutes. The experimental teachers were three females recruited from an undergraduate education course at the Pennsylvania State University. They were trained in special sessions and an extensive pilot study in order to teach in an inquiry and didactic manner and to establish cooperative and competitive goal structures. They were then randomly assigned to teach the four treatment conditions. One of the teachers taught two classes while the other two taught one class each. Since these three students were not certified teachers, their instructional competency was questionable even though they had the training to teach in the specified conditions.

A one item questionnaire given to the students after the lesson indicated the students in the cooperative condition worked with other students more than did those in the competitive condition.

Data analysis indicated an interaction effect existed between the teaching style (inquiry, didactic) and learning structures (cooperation
versus competition) on the student acceptance of the teaching method. Students in the competitive-inquiry condition disapproved of the way the lesson was taught significantly more than did students in the cooperative-inquiry condition. The analysis of approval of the teacher also yielded an interaction effect that approached significance. The researchers concluded that student approval of the teacher did parallel student acceptance of the teaching method. Students in a cooperative goal structure, compared to students in the competitive condition, indicated that they liked being with the other students in the session. Cooperatively linked students also believed they had learned more from the lesson than did students who were competitively linked. However, students in the competitive condition did not rate their acceptance of the didactic teaching method significantly greater than did students in the cooperative goal structure. The researchers concluded that cooperation promotes positive attitudes toward both the teaching methods and the teacher, but competition does not uniformly promote negative attitudes.

Johnson et al. (1980) used a 3 x 1 ANOVA to investigate whether individuals in the cooperative condition would perform better than individuals in the competitive and individualistic conditions on all the problem solving tasks included in this study. Whether the medium and low ability students in the cooperative condition would benefit from their interaction with the high ability students, and greater support and encouragement for learning was also investigated.

Two first grade classes (45 students; 27 males and 18 females) were randomly assigned to conditions stratified on the basis of gender and
ability. Reading and math abilities of students were used to indicate students' ability.

The researchers reported that the cooperative, competitive, and individualistic learning situations and three different learning tasks were the two sets of independent variables in this study. In actuality, the tasks were used as dependent measures.

The first task, adapted from the one used by Salatas and Flavell (1976), was a categorization and retrieval problem in which students were required to memorize 12 nouns during a study session and to complete several retrieval tasks during a subsequent testing session. The second task was a spatial-reasoning problem called the Rasmussen Triangle (Napier & Gershenfeld, 1973) and consisted of a diagram containing an ambiguous number of triangles. The third task was a verbal problem solving task consisting of ten math story problems given to the students and also read orally by the teacher. No discussion of design and validity of these instruments was given.

The task achievement was used as a dependent measure during a subsequent testing session. The quality of the strategy used for each of the tasks, and perceptions of peer support for learning were also investigated. It is noteworthy that although tasks cannot be determined to be reliable variables, students' performance on such tasks should be. Achievement scores were derived from the individual tests and turned in at the end of the second, fourth, and sixth instructional sessions. On the seventh day of the study, students were individually asked three questions. The teachers recorded the students' responses on four-point scales. The validity and reliability were not reported for these instruments.
Prior to the study, all of the students participated in cooperative, competitive and individualistic learning situations to familiarize themselves with the learning skills which fit the learning situations. All students then participated in six instructional sessions of 60 minutes each. Each instructional session was on a different day. The three teachers were randomly assigned to conditions. Two of the three teachers participating in the study had received 30 hours of training in using the three different goal structures prior to study. The third teacher was a college professor who was competent in teaching the three different conditions. A teacher effect might have existed because different classes were taught by different teachers. No classroom observations were made to validate intended treatments.

No significant differences were found among conditions on "how much students liked the condition they were working in" and "how important it was to them to do well on the learning tasks." The researchers further concluded that students in all three conditions enjoyed the operationalization of the condition and took the learning tasks seriously. On the other hand, the high ability students in the cooperative condition consistently performed higher on the problem solving tasks and used superior strategies for deriving their answers than did the high ability subjects in the competitive and individualistic conditions. The researchers reported that the superior performance of the cooperative learning groups was not due to the high ability members giving the answers to the medium and low ability students, but rather was due to the discussion process in cooperative groups, which resulted in the development of superior cognitive strategies for solving problems. The
implication of this study was that when high problem solving performance (the use of effective strategies, peer support and encouragement) is desired, the instructional situation should be structured cooperatively rather than competitively or individualistically. It should be noted that compared with the previous studies, which were often conducted to examine the relative effects of cooperation and a "traditionally taught" control group, this study compared all three goal structures which may be utilized in actual teaching. The research design of this study was more rigorous than observed in most of the other studies.

Okebukola (1985) employed a study to examine the relative effectiveness of two "pure" cooperative, two cooperative-competitive, and one "pure" competitive learning technique on students' performance in science. These various techniques were based on three models: "pure" cooperation (e.g., Johnson & Johnson's technique, Jigsaw technique), cooperation-competition (e.g., Teams-Games-Tournament [TGT]), (Students Teams Achievement Division [STAD]), and "pure" competition (e.g., Individual Competition). Five experimental groups and one control group were used. The 630 eighth grade students from six randomly selected junior high schools in the Ilesa Local Government Area of Oyo State, Nigeria were involved in this study. Five volunteer final-year preservice science teachers served as experimental group teachers and were randomly assigned to selected schools. But, one regular science teacher served as the control group teacher. There was a possible teacher effect because different teachers taught in each treatment group and preservice teachers were used.
The Science Achievement Test (SAT) consists of two subtests of 20 items each was used to collect performance data. The subtests related to low (recall and knowledge) and high (application, synthesis, and evaluation) cognitive levels. The researcher compared the students' gains on the high cognitive level and low cognitive level subtests for the data analysis. The face validity seemed to be acceptable according to the description of the validation procedure. The content validity was obtained by asking four experienced science teachers and a specialist in test construction to criticize the initial 63 test items. However, the details of the formalized process for establishing content validity was not given. Gronlund (1985) stated that content validity of a test must be based on meeting the objectives (what has been taught) of classroom instruction, students' achievement domain (what is to be measured) and the test itself (a representative sample of test items). Construct validity was not reported. The test-retest reliability of the SAT was .82. Internal consistency was .84 for the final 40 items of the SAT.

Experimental teachers were given a total of 27 hours of intensive training. Each teacher was trained to teach identical lessons based on Units 1 and 2 of Book 2 of the Nigerian Integrated Science Project. Control group students were taught based on the traditional whole class method, and experimental classes were divided into five-member groups which were heterogeneous in ability and gender. The students' ability levels were classified by the SAT along with the students' most recent academic record in integrated science.

The observation frequencies confirmed that the various techniques were implemented correctly by the teachers using a five-man observation
team with a ten-category instrument, modified from Peterson and Janicki (1979). Ten randomly selected lessons for each teacher were observed. A chi-square test of homogeneity on the observation frequencies also confirmed treatment differences.

The result of analysis indicated that for the students' performance in science, significant differences existed between experimental and control groups. Further analysis indicated that five experimental and control groups were found to differ significantly from one another by using a t-test. But, TGT and STAD groups failed to differ significantly. It was inappropriate to use a t-test for post-hoc comparisons. The five experimental techniques were later blocked into three groups: "pure" cooperative (Johnson & Johnson's and Jigsaw), cooperative-competitive (TGT and STAD), and "pure" competition (individual competition). It was found that the cooperative-competitive methods had greater positive effects on students' performance in science. TGT and STAD were found to promote mean gains of more than 23 points (total points was 40). Compared to the mean of pretest for STAD group (7.08 points), this was a significant gain. The results further suggested the superiority of TGT and STAD in promoting students' performance in science as compared to the other techniques. Students instructed using the STAD and TGT techniques were also found to perform significantly better on the high cognitive skills than students in other groups.

The researcher concluded that students instructed using a combination of cooperation and competition, such as STAD and TGT techniques, performed significantly better than the students instructed in other models. This finding may explain why science students in the
individual competition group acquired practical skills better than the "pure" cooperation group (Okebukola & Ogunniyi, 1984). But, it should be considered that the possible effect of the preservice teachers would confound the results of the study.

Okebukola (1986a) conducted another study by using a 2 (cooperative preference versus competitive preference) x 2 (cooperative treatment versus competitive treatment) factorial design to examine the effects of environmental influence on habitual behavior patterns (eco-cultural factor) on students' achievement in science under cooperative and competitive learning conditions. The eco-cultural factor in this study was concerned with the preference shown for cooperative and competitive situations.

The experimental sample consisted of 493 ninth grade biology students enrolled in four junior high schools. Two of these schools were randomly selected from a rural district, and the other two schools were randomly selected from an urban center.

The subjects of this study came from two different environmental situations and were assumed to have specific behavior patterns. Cooperative work was considered to be typical for rural communities, while the inhabitants of urban communities were expected to exhibit competitive behavior. A modified form of the Learning Preference Scale (LPS) (Owens & Straton, 1980) was used to measure students' preference for cooperative or competitive work. A maximum score of 100 was possible on LPS. A range of scores of 0-49 indicated preference for cooperative work. Reliability was .91. Validity was not discussed. The BAT test, which consisted of 50 items, was used to measure students'
achievement. The different samples of 86 students were used in the process of validation. But, content validity as well as construct validity were not indicated.

Eight volunteer preservice biology teachers were subjected to an intensive training program to equip them with the necessary pedagogical skills for implementing their assigned modes and to ensure that a high degree of homogeneity would exist in the manner with which teachers taught the lessons within a particular treatment condition. At the end of the training, only four teachers actually implemented the treatment. A two-man observer team using an instrument modified after Peterson and Janicki (1979) was used to collect observational data on cooperative and competitive interactions, and to confirm that the teachers were correctly implementing the applicable treatment. No validity was mentioned for this observation instrument, however, interrater reliability of .94 was obtained. Two of the teachers were assigned to the cooperative condition and the other two were assigned to the competitive condition. In a particular district, two schools were chosen. One school had a cooperative group teacher while the other school had a competitive group teacher. It is questionable that the preservice teachers could instruct appropriately in the specifically assigned conditions. Further, it may be better to assign the same teacher to teach in two different conditions to minimize the possible teacher effect. Both tests of BAT and LPS were administered to all the the students just before the treatment started. In the two rural schools, 222 of the 242 students (91.74%) expressed preference for cooperative work. However, 198 out of the 241 students
(82.16%) in the two urban schools expressed preference for competitive work.

The goal structure of the class was decided by the assigned teacher. If the students of the class were taught by a cooperative group teacher, then this class was assigned to a cooperative treatment. The treatment lasted for six weeks. The time use of each lesson was teacher review and introduction (5 minutes), discussion of the task for group/individual work (7 minutes), and the progress of the group/individuals (40 minutes). The BAT was administered as a posttest. The result of analysis showed that a significant interaction existed between treatment and preference for cooperative or competitive work. Students who had preference for cooperative work and had instruction on a cooperative basis had a significantly greater mean score (35.93) than students who had preference for cooperative work and had instruction on a competitive basis (20.19). Students who had preference for competitive work and had instruction on a competitive basis had a significantly greater mean score (36.82) in comparison with students who showed preference for competitive work and had instruction on a cooperative basis (21.23). The researcher further stated that the main effects for treatment and preference were significant. It is wrong to determine main effects when an interaction effect exists. Further, it was not appropriate to use the number of students as the unit of analysis when intact classes were actually selected. When comparisons were made between "matching" preference/treatment groups, students who were instructed in line with their preferences in the cooperative and competitive conditions did not differ in achievement. Students who were not instructed in line with
their preferences in the cooperative and competitive conditions also did not differ significantly.

Okebukola concluded that the eco-cultural factor affects students' preferences for cooperative and competitive work. Students will do equally well in cooperative and competitive conditions as long as they are placed in the learning setting which matches their preferences. Therefore, the controversy over the relative effectiveness of cooperation and competition may be resolved if the mediating variable of learning preference of students can be recognized.

Johnson et al. (1986) employed a 3 (three conditions) x 2 (male, female) factorial design to examine the effects of computer-assisted cooperative, competitive, and individualistic instruction on achievement, student-student interaction, and attitudes toward computers.

Seventy four eighth-grade students (ages 11-13) were randomly assigned to three conditions, stratifying for gender, handicap, and ability level. The definition of handicap and the selection of ability level were not given.

All students were involved in a ten-day instructional unit that paired a computer simulation with written materials on the fundamentals of map reading and navigation. A modification of a computer simulation named Geography Search was used in this study. The daily instructional sessions lasted 45 minutes. Each condition was assigned to a separate classroom and given six computers. The amount of computer time available to each student was balanced across conditions. Three certified teachers with over 90 hours of training in structuring cooperative, competitive, and individualistic learning were
involved in this study. In order to minimize possible teacher effects, the teachers rotated among conditions. Observation of classrooms was conducted by three research assistants to verify that the conditions were being implemented appropriately. But, the content of the observation instrument and the observation data were not known. The interrater reliability was .80 (using the percentage method of agreement and disagreement for occurrence, quality, and direction).

Three different conditions; cooperative, competitive, and individualistic learning and gender were the independent variables. For the cooperative learning condition, each student would complete individual daily worksheets. But, this arrangement seemed to conflict with the characteristics of cooperative learning. It would have been better for the students working in the same group to turn in a single group lab report. In this study, the group members were also assigned specific roles, such as captain, navigator, meteorologist, and quartermaster. Role assignment was thought to promote cooperation within the group and thereby improve students' achievement.

The four dependent variables were: (a) the achievement measures consisting of daily worksheets, the final examination, and the success of the students in accumulating gold. Daily worksheets were used to test students' comprehension ability to apply the reading material assigned that day. The final examination consisted of 16 multiple-choice items that measured factual recognition, application, and problem solving; (b) the oral interaction measure, which consisted of observing students' task, management, and social interactions. The researchers stated that the observation instrument had been validated in previous studies and had a
reliability of over .90; (c) a sociometric nomination instrument was used to measure students' perceptions of each other by asking them to list the names of up to five classmates they would like to work with in a future cooperative group. If the members of the same group indicated that they would like to work together, it may indicate that the levels of cooperation were satisfactory for their learning experience; and (d) the attitude tests of 39 items included a 12-item Liking-for-Computers Scale, a 5-item Computers-Are-a-Male-Domain Scale, a 6-item Necessity-of-Computer Scale, a 4-item Cooperation Scale, a 4-item Individualistic Scale, and an 8-item Competition Scale.

The results of this study can be divided into four parts, with each part including several subordinate results. The serious problem of data analysis was that, overall, 33 comparisons were made creating a problem of accumulated error rate (Good, 1984). The results indicated that for the achievement measure, students in the cooperative condition completed more worksheet items; accumulated significantly more gold, correctly answered more worksheet items and tended to score higher on the final examination (e.g., factual recognition of material learned, application of the material being learned, and problem solving) than did the students in the competitive and individualistic conditions. The interpersonal interaction data indicated that students in the cooperative condition made 2.90 statements per minute, while students in the individualistic condition made 0.86 statements per minute. Further, more task statements were made in the cooperative condition than in the other two conditions, and students in the cooperative and competitive conditions addressed more statements to their peers than did the students in the
individualistic condition. Students in the cooperative condition addressed a higher percentage of statements to other students and a lower percentage of statements to the teacher than did the students in the other two conditions. The sociometric data indicated that students in the cooperative condition nominated more female classmates as desired for future work partners than did students in the other two conditions. It should have been clearly stated whether students' nomination was truly based on the experience of cooperation within the group or not.

The result of the attitude measure indicated that students in the cooperative condition perceived themselves as engaging in more collaborative behaviors than did the students in the other two conditions whereas students in the individualistic condition perceived themselves as engaging in more individualistic behaviors than did the students in the other two conditions. The students in the cooperative and competitive conditions liked computers more than did the students in the individualistic condition. Students in the competitive condition believed that computers were more necessary for future success than did the students in the other two conditions. Males perceived computers as being more of a male domain than did females. However, the data indicated that the students of the competitive learning condition had the higher scores for these two subscales than the students in the other conditions.

Johnson et al. concluded that computer-assisted cooperative instruction promoted greater quantity and quality of daily achievement, more successful problem solving, more task-related student-student interaction, and increased the perceived status of female students.
Lazarowitz et al. (1988) investigated whether a change in the instructional procedures from a competitive, individualistic approach to a cooperative approach would affect students' on-task behavior and their academic achievement. A modified jigsaw method combined with the investigative group approach was used for this study.

The subjects were selected from four intact classes of 10th grade general biology (n = 113). Two classes were randomly assigned to the experimental group. The other two classes were the control group. All of the students were given the General Aptitude Test Battery (GATB) which includes four subtests: general learning aptitude, verbal aptitude, numerical aptitude and spatial aptitude. The control group had higher scores than the experimental group in each subtest. Two classes of the experimental group were divided into groups containing five students, each group: (a) consisted of boys and girls, and (b) was made as heterogeneous as possible in ability level. Then, these groups were given three days of team-building activities directed toward teaching group dynamics skills. The last 10-15 minutes of class each day was used as an evaluation period. Students filled out evaluation forms to help determine the group's performance. The time line for learning one unit of material for the experimental group was three days of team-building, three days of counterpart group learning, five days of jigsaw group teaching, review (one day), and the posttest. The time line of the control group was not reported. However, students in the control group were taught in a traditional teacher directed manner. Emphasis was put on not letting the students work together in any kind of groups. The students of both groups used the same guide sheets. The materials for both groups were
prepared units on the cell and plants which were from the BSCS (Biological Science Curriculum Study) Green Version (1978). Each unit for the experimental group was divided into six approximately equal portions. Considering that the students were divided into groups of five, it would have been more appropriate for each unit to be divided into five sections instead of six. Then, each student in a group could be responsible for one portion of the unit. The length of the study was seven weeks in both groups. A teacher trained in the jigsaw method and an aide instructed the experimental group, while the control group was taught by a different teacher and aide. There may have been a teacher effect because different teachers taught in different conditions.

As for the instrumentation, pretests in biology subject matter were given to determine the student entry knowledge for each unit. Posttests were given to determine the gain in cognitive learning for each unit. Both of these tests were developed by teachers in the science department of the school. The content validity was established by a panel of three teachers and two science educators. However, the details of the panel's work were unclear. Also, construct validity was not reported nor was reliability indicated.

Two teaching assistants observed "on-task behavior" in both the experimental and control classrooms. One pre-observation was made during the week prior to the beginning of the study; four observations were made during instruction and four observations were made after completing the study, with an interval of two weeks between each observation. Each student was observed for 30 seconds at a time, three times during the period.
On-task and off-task behaviors were recorded. The totals were figured and a percentage for on-task and off-task behavior for the experimental and control group were analyzed and computed. Inter-observer reliability was .81. The researchers did not clearly define the categorization of on-task behaviors or off-task behaviors. The students of the experimental group could work together, while the students of the control group could not. This difference in arrangements could have influenced students' on-task behaviors. In fact, the students of the control group may have been easier to observe and categorize as off-task because they did not have an opportunity to interact with other students. On the other hand, the students of the experimental group might have been coded to be on-task because they were discussing or listening to other group members even though they were talking about something unrelated to the lesson. Such differences may make the results unreliable. According to a study by Gallagher and Tobin (1987), students may be actively engaged mentally in the learning process, with some of the students engaging in learning overtly much or all of the time. Therefore, if the criteria of on-task behavior were clearly defined, the results would be more valid and reliable.

The collected data indicated that the experimental group (during: \( \bar{x} = 78\% \), post-lab: \( \bar{x} = 71.5\% \)) displayed a greater frequency of student on-task behavior during and after the experiment than the control group (during: \( \bar{x} = 65.75\% \), post-lab: \( \bar{x} = 61.5\% \)). In the cell learning unit, experimental group students (\( \bar{x} = 61.75 \)) received significantly higher mean scores than control group (\( \bar{x} = 57.69 \)) students. However, in the plant learning unit, the control group (\( \bar{x} = 77.80 \)) did significantly better.
than the experimental group (\( \bar{x} = 67.00 \)). The researchers attempted to explain why different results occurred in academic achievement. They felt that it was possible for differences in the content of the two units, and also the nature of the tasks which students were required to perform, to contribute to the different results. It can be concluded that the cooperative and small investigative group method resulted in higher pupil on-task behavior and low off-task behavior.

Sherman (1989) conducted a study to compare the effectiveness of a cooperative (Sharan's group investigation model) versus an individually competitive structure in two secondary biology classrooms. "Individually competitive" was interpreted to mean a competitive learning structure. The students studying in the competitive learning structure could not work together with other students in the classroom.

The two classes were of approximately equal academic abilities in terms of a pretest which was a teacher-made 40 item test. Class A (n = 21) used the cooperative GI (Group Investigation) strategy; class B (n = 25) received the individually competitive treatment. The method for sampling subjects and assignment to experimental or control group was not indicated. Twenty five percent of the student's fourth-term grade consisted of a research project concerning major biomes of the world. Both classes were exposed to the same study content, labs, in-class activities, homework, reading materials, and the same instructor for seven weeks. They differed only in the classroom learning structure which was utilized. However, the researcher mentioned that only three weeks were needed to complete the research project. The remaining four
weeks of study may have had an effect on the result of this study. No classroom observations were made to validate treatments.

Class A students (GI technique) were divided into groups of four to five members who were heterogeneous with regard to academic ability, gender, and race. This resulted in five groups with each group being randomly assigned to a particular topic of a major biome (tundra, coniferous forest, deciduous forest, grassland, desert, or tropics). A criterion referenced evaluation system was used to determine grades for the entire unit of instruction. Class B students worked competitively on all class activities throughout the seven week unit. A classroom-based norm referenced evaluation system was used to determine grades in class B.

During the three weeks used to complete the research project, two entire class periods were used to work on research projects for both classes. All other activities related to this assignment were conducted out of class.

A teacher-made test which included 40 multiple-choice questions, was used for both pretest and posttest. The reliability for the posttest was .71 by using KR-21. Face validity of the test was assumed given that the content of the items were relevant to the specific objectives of the unit of study. No information on content validity and construct validity was given.

The correlation between pre- and posttest scores for both classes A and B pooled together was statistically significant indicating that nearly 37% of the variance in posttest scores was predicted by the students' pretest scores. This supports the view that ANCOVA should have been
used. The interaction effect between treatment and time (pretest versus posttest) was not significant. Posttest scores were significantly greater than pretest scores for students in both treatment groups. But, it was inappropriate to use student numbers as the unit of analysis because intact classes were selected. No significant differences in pretest or posttest scores between treatment groups were found. This data indicated that both cooperative and competitive techniques were almost equally effective learning strategies. Neither of the strategy was superior over the other in producing achievement gains.

Summary

Overall, most research studies of cooperative learning in science classrooms indicates its superiority over other goal structures. But, the levels of cooperation within groups were rarely assessed and classroom observations to assure the implementation of intended conditions were rarely undertaken. Therefore, the relationship between the treatment and students' learning outcomes can not be represented as a simple cause and effect situation. Further, use of the wrong unit of analysis, possible teacher effect (assigning different teachers to teach in different classes may cause a teacher effect), preservice teacher effect (preservice teachers were often assigned to teach in the intended conditions), students' unfamiliarity with collaborative behaviors, the lack of description on the nature of tasks, and questionable validity and reliability of the instruments create problems of interpretation and necessitate additional research in this area.
Laboratory Teaching Strategy in Science

"Hands-on" experiences (laboratories) are considered essential to the learning process, especially for the vast majority of secondary school students who have yet to master the most sophisticated and abstract reasoning patterns. The laboratory provides students with an opportunity to do science rather than to learn about science (Bates, 1982). However, each type of laboratory approach has characteristics that clearly differentiate it from other approaches. As a result, different outcomes may be obtained from different laboratory emphases (Collette & Chiapetta, 1984). Many research studies have been done by comparing the effect of lab versus non-lab, but the student-student interactions within the group were rarely investigated. The effectiveness of laboratory activities may be highly related to the students' group cooperation. If the lab can be taught in a cooperative atmosphere, the students' achievement might be improved. Therefore, the intent of reviewing the laboratory teaching strategies in science was to compare the implementations of different laboratory teaching strategies, desired students' outcomes, students' group cooperation, teachers' time use, systematic observation of students' and teachers' behaviors, instruments of measuring students' achievement under different types of laboratory instruction such as deductive versus inductive, structured versus unstructured, expository versus discovery, and verification versus guided discovery.
The results of research indicate that different teaching strategies may accommodate different learning styles of pupils

Comparing the effects of different kinds of laboratory teaching strategies on students' outcomes

1. Structured
2. Teacher structured
3. Traditional
4. Deductive
5. Teacher demonstration
6. Hands-on
7. Inductive
8. Inquiry
9. Student structured
10. Unstructured

Figure 2. The basic model for most of the research designs on laboratory teaching strategy
Figure 2 on the preceding page illustrates the basic model for the research designs used to investigate laboratory teaching. Comparing the effect between any one of the five methods on the left with another from methods 6-10 on the right side is the typical approach. Several studies provided evidence to support the inductive method (Egelston, 1973), discovery method (Raghubir, 1979), and student structured laboratory (Spears & Zollman, 1977) as a way to facilitate students’ inquiry skills, understanding of science processes, and achievement in science.

Figure 3 on the following page illustrates a two dimensional categorization of the different kinds of laboratory teaching strategies which were reviewed. The x-axis indicates a continuum of laboratory teaching strategies from the verification type to the discovery oriented type. The y-axis indicates the extent of control by the students or teacher in the laboratory activities.

The research indicated that completely structured or unstructured laboratories did not show a clear difference on the concepts learned or manipulative skills mastered. A strategy which integrates the strengths and advantages of both the teacher structured and student structured methods may provide promising results for students’ learning in science (Lunetta & Novick, 1982). The "o" in the first quadrant in Figure 3 indicates that the most appropriate way of implementing the secondary science laboratory is to include both the strength of a teacher’s structured investigation and discovery method.
Zingaro and Collette (1968) compared the effects of two methods (inductive versus traditional) of teaching physical science to college sophomores. The population for this study was 793 sophomore students registered in Physical Science 203. Finally, this class involved 15 instructors and 33 sections of students, each section being limited to 24 students. Each of three instructors was responsible for one control group (C) and one experimental group (E). This study included six sections and three instructors. The researchers reported that each student from the accessible population had an equal chance to register in any one section. But, this may not be true in a pure sense, as it is dependent upon the rest of each subject's schedule.
An inductive laboratory method was used to teach three experimental groups. Students did not have formal lectures but were expected to discover principles from analysis of data collected in the laboratory. On the other hand, a traditional laboratory method was used to teach the three control groups. Students had formal lectures followed by laboratory experiments. The laboratory experience verified principles already presented in the lectures. The topics studied during this investigation included measurement, force and motion, mechanics of fluids, kinetic theory, chemical change, and macroscopic-microscopic systems.

Four instruments were used for both pretest and posttest. The Physical Science Subject-Matter Test was constructed by the researchers. The content validity was established appropriately by considering which topics should be covered, and test items were developed as a representative sample of testing students' outcomes which had been specified in the objectives for teaching. Reliability obtained by the Spearman-Brown split-half technique was .85. The Test On Understanding Science (TOUS) measured the students' understanding of the methods and nature of science. This was a standardized test with 60 items developed by Cooley and Klopfer (1961). No validity or reliability was indicated. The Physical Science Critical Thinking Appraisal was prepared by the researchers. Most of the test items involved measurement of the student's ability to interpret data presented in the form of reading passages or graphs. An item analysis resulted in dropping 17 items and retaining 71 items. The researchers said that the validation procedure was similar to the Physical Science Subject-Matter
test. Reliability calculated by Spearman-Brown split-half technique was .71. No information on construct validity was reported. The Watson-Glaser Critical Thinking Appraisal was employed to measure critical thinking ability in non-science areas. No validity or reliability was reported. This test was used to determine the degree of relationship between achievement on the Watson-Glaser Critical Thinking Appraisal and achievement on the Physical Science Critical Thinking Appraisal. This procedure provides a correlation with measures of similar constructs, and establishes concurrent validity.

The study lasted 14 weeks. The pretests were completed within the first two weeks. No classroom observations were made to validate the teaching approach. Regents Scholarship Examination scores were used to control individual differences in scholastic aptitude, and pretest scores were used to control individual differences in academic ability.

The results of data analysis supported the inductive laboratory method as superior to the traditional laboratory method in terms of student achievement on the Physical Science Critical Thinking Appraisal. But, both methods were equally effective in teaching facts and principles in physical science.

Babikian (1971) used a 2 x 3 factorial design to examine the relative effectiveness of discovery, laboratory, and expository methods of teaching science concepts. The sample consisted of nine classes of eighth-grade students (approximately 250 students). Students were randomly assigned to three science teachers. Each teacher received about 82 students. Students who had missed one or more sessions, and had no I.Q. scores were eliminated when the data was analyzed. In order to have 24
students (12 boys, 12 girls) in each section, one or two students were randomly eliminated from the classes. Finally, nine homogeneous classes (fast, average, and slow) were obtained. These classes were randomly assigned to three teaching methods. The study lasted three weeks, but for each week only one teaching method was used by the investigator to teach three classes. Four sessions of teaching six concepts centered around the principle of buoyancy in liquids (Archimedes' principle). The expository method required no laboratory equipment. The teaching was entirely verbal, except for occasional use of the chalkboard. The students were provided with worksheets which ensured the attention and the participation of the students. In the laboratory method of instruction, the teacher presented the concepts as well as the procedural instructions for students' verification in a printed laboratory manual, and provided each student all of the equipment necessary for verifying each of the individual concepts. For the discovery method, the students were provided with the procedure only for the discovery of the concept. No classroom observations were made to verify treatments.

Two tests were used for pretest, posttest and retesting. The pretest consisted of six short questions which were used to measure the students' acquisition of the introductory concepts of weight, volume, and density and six questions to assess the students' prior knowledge about the six concepts of the learning task. No data for validity and reliability were indicated. The pretest scores were used to compare the difference among the treatment groups before the learning task. The posttest consisted of 38 items and was further subdivided: six items to measure the verbalization of the concepts, ten items of each to measure the recognition of the
concepts, the ability of the students to transfer the concepts to new situations, and the ability of the students to apply the concepts in numerical problems, and two items to measure the ability of the students to use the concepts to discover new concepts. These categories were very similar to Bloom's categories for the cognitive domain of educational objectives. The researcher stated that the content validity of the pretest was established by five physics professors at University of California - Los Angel. But, no further information was given. The reliability was .76 using the KR-20 formula, which was determined from the scores of 300 students in 13 seventh and eighth grade classes. But, the subjects of this study were eighth grade students. The content of retest items was not reported. Both the I.Q. and pretest scores of students in nine classes did not differ significantly from one another. However, no statistical comparison was performed. The results of the posttest scores were reported by a three factor randomized design. In fact, ANCOVA analysis could have been used to adjust for the initial differences among the groups.

Babikian concluded that the expository and the laboratory methods were significantly more effective than the discovery method for teaching science concepts to eighth grade students, with respect to the following criterion measures: overall achievement, verbalization of concepts, recognition of concepts, and the application of concepts to numerical problems. Further, irrespective of the method by which students in the upper I.Q. group were instructed, they achieved significantly better than those in the lower I.Q. group on all criterion measures. Irrespective of the method used to instruct boys, their achievement was significantly
better than girls, with respect to the following criterion measures: overall achievement, recognition of concepts, and transfer of concepts.

Babikian also mentioned that the results of this study could not be generalized to all phases of science education, but rather to the teaching of science concepts, by a particular expository, a particular laboratory, and a particular discovery method, at the junior high school level. Perhaps, the lack of prior experience on the part of the students in discovery methods may be one of the factors which caused the poor performance observed when using this method. Further, in the laboratory and discovery methods, the students were informed that they could not cooperate with each other. This arrangement seems to conflict with what actually occurs in the classroom. It is very difficult for junior high students to conduct a laboratory without cooperating or interacting with other students.

Egelston (1973) compared two groups of high school biology students and teachers with respect to teaching method and resultant behavior, learning climate and achievement. The experimental and control groups were composed of 86 and 90 students respectively. Nine experienced volunteer teachers of high school biology from urban and suburban schools were randomly assigned to two groups (five teachers were assigned to an experimental group, four teachers were assigned to a control group). Since each class was taught by a particular teacher, a possible teacher effect could occur.

A cell physiology unit and nutrition unit containing ten laboratory exercises was designed to fit the curriculum for high school biology. The control group was given a set of exercises requiring the deductive process,
and the experimental group received a parallel set based upon the inductive process. Each exercise was completed in a single laboratory period. The inductive method was defined as a laboratory in which an open-ended approach focused on the problem in an experiment containing few specific directions. The exercise contained few clues concerning the observations and no particular conclusions were identified for the students. All concepts were initially explored in the laboratory and all discussion was undertaken in subsequent classwork. The traditional (deductive process) method was defined as a laboratory in which the activities were fully described with each step of the procedure followed by specific objectives. The observations and conclusions were implied by the directions in advance of the activities. All concepts and facts were first covered in class and then verified in the laboratory. However, it was not known how lab activities were validated to fit the two approaches.

At the start of the school year all students were pretested for knowledge of cytology and cell physiology. The reliability and validity of measures were not given. Ten short quizzes were conducted following the laboratory exercises. Quiz length varied from 7-11 items, and scores were recorded as percentages. Again, no reliability and validity were mentioned for the ten quizzes.

Each laboratory exercise was observed and coded by a college student. Seven of the eight observers had previous training using Flanders' category system. All eight received at least ten hours of training using the Egelston category system (a category system developed by the researcher) plus at least two practice sessions prior to their field
laboratory observations. All observers had attained nearly 100% accuracy by the end of the training session. The procedure for calculating accuracy was not indicated. Data on classroom behavior were obtained by means of the Egelston category system. The Egelston category system includes five kinds of behaviors as follows: teacher-indirect (1-4 categories), teacher-direct (5-9 categories), pupil-independent (10-13 categories), pupil-dependent (14-16 categories), and other (17 categories). Prior to analysis these data were separated into three sets: (a) teacher-pupil interaction behavior, (b) student behavior, (c) teacher behavior.

Teachers were allowed to determine the content, pace, and context of the laboratory unit. No data were collected concerning other lab exercises which may have occurred during the unit. The researcher did not explain why the instruction of ten consecutive laboratory activities was not scheduled. In order to investigate whether the classroom climate of the teachers using the inductive method of teaching was different from that of the teachers using traditional methods, the Learning Environment Inventory (LEI) was administered to all students at or near the end of the laboratory exercises. This instrument consisted of 14 scales containing seven items each. No validity or reliability was indicated. A multivariate one-way analysis was conducted on the data collected from the LEI.

The data analysis on the set of ten quizzes indicated that when the two groups were statistically equated for entering behavior, the control group initially surpassed the experimental group in lab quizzes, but the positions were reversed by the end of the study. The researcher's interpretation was that initially the students within the experimental group did not have much experience with the inductive method, while the
control group had several years of experience with traditional methods of instruction. The two groups were significantly different in the socioemotional climate of the classroom. Univariate $F$ ratios were significant for seven of the 14 scales, the control group exhibited significantly more intimacy, satisfaction and diversity, while the experimental group was significantly higher on the scales measuring apathy, formality, goal direction, and disorganization. For the teacher-pupil interaction, the pooled group of five teachers assigned to the experimental method varied significantly from that of the pooled control group. The amount of direct behavior for the experimental group was only slightly less than the control group; however, the indirect behavior of the experimental group was significantly more than that of the control group. On the other hand, the total amount of student behavior was nearly identical in percentage for both groups, with the control group students exhibiting nearly twice the amount of independent behavior. The researcher explained that it was likely that the nature of the direct teaching behavior during the laboratory introduction was the reason for such a discrepancy. For example, a teacher's question, while classified as indirect behavior, may demand a "dependent" factual response without allowing student-initiated comments. Conversely, a directive and unclear question may stimulate a multitude of student questions. Or, the control group students were given a thorough laboratory introduction and thereby exhibited more independent behavior during the actual laboratory exercise.

The researcher also mentioned that the teacher-pupil interaction data was collected mainly from the first few minutes of each lab when the
teacher reviewed the material and directed the students to begin the activity. However, for a few classes this data was collected at the end of the activity as the teacher led a discussion about the results and conclusions. In this case, the data collected from different portions of the period may show different results of teacher-pupil interaction patterns and complicate the results. There was an overwhelming difference in the amount of direct and indirect supervision by the two groups of teachers. This difference was one effect of the teaching approach. Experimental group teachers used little direct guidance while their students struggled to solve the problems presented in the laboratory activities. Control group teachers gave considerable assistance to their students during the laboratory activity. Pupil behavior was significantly different for the two groups. Students in the experimental group were more independent than the students of the control group. The pupil behavior meant that students worked on individual work. However, when the introduction/discussion was led by the teacher, students of the experimental group tended to show dependent behavior. It was noteworthy that the appropriateness of categorization for pupil-dependent behavior may be challenged and debated in the Egelston category system. For instance, "Response to Teacher's Question" may not be considered to be a completely dependent behavior. "Seeks Assistance" could be interpreted to mean that students tried to glean as much information as possible before conducting the laboratory. But, these two behaviors were categorized as pupil-dependent behaviors in the Egelston category system.

The inductive method yielded significantly different results for laboratory behavior as well as for the learning environment in the
classroom and academic achievement in comparison to the traditional deductive method. The novelty of the inductive method may initially hinder achievement, but will eventually facilitate it.

Spears and Zollman (1977) examined whether the instructional structure of the activity will influence the degree of understanding of the process of science.

The sample was comprised of the students in four lecture sections of Man's Physics World I during the spring semester, 1973. The subjects of this study were typically referred to as non-science students by the college instructors. The subjects were randomly assigned to the four lecture sections and optional laboratory. The number of students was not given. The two different laboratory strategies were not specified in the course listings. Since some students were absent for either the pretest or posttest, and others failed to complete the form, about 50% of the students returned usable data. The percentage of usable data was low.

The independent variable was the type of laboratory experience (structured laboratory versus unstructured laboratory). In the structured situation, the students were given somewhat specific instructions on how to perform the experiment and treat the data, while in the unstructured situation little or no instruction was given. But, no classroom observation was made to validate treatments. The dependent variable was the students' understanding of science as measured by the Welch Science Process Inventory Form D (SPI). SPI is a dichotomous rating scale which includes 135 statements concerning the processes of science. Reliability was .86 using the KR-20 formula. Predictive validity and construct validity have been established by Welch and Pella (1967). The SPI
instrument was constructed by considering four major elements of the scientific enterprise as (a) Assumptions, (b) Activities, (c) Nature of Outcomes, and (d) Ethics and Goals. No significant differences occurred in the components of Assumptions, Nature of Outcomes, and Ethics and Goals. But, students in the structured laboratory scored higher on the component of Activities.

Spears and Zollman concluded that the structure provided examples of the activities of scientists and caused the students to learn better the process of science. The researchers also suggested that unstructured laboratories can provide useful experiences for students having prior experience in scientific experimentation. But the average college freshman or sophomore taking his/her first physics class requires a structured experience and training in the scientific process.

Stallings and Snyder (1977) attempted to determine if ISCS (Intermediate Science Curriculum Study) facilitated inquiry skills in students. The subjects of this study were selected from two county school systems that were judged by the researchers to be similar. However, no data were given to support this assumption. Four cooperating teachers were involved with this study. One of the systems had been using ISCS for the previous two years. The curriculum that was used by the other system was not indicated, and simply called a non-ISCS group. The two systems were judged by: (a) a questionnaire which was completed by the student, from which his/her socioeconomic class was estimated, along with his/her educational goals; (b) an estimate of each student's mental ability, which was measured by the California Test of Mental Maturity; and (c) descriptions of the teacher's classroom behavior which were
collected via the Science Curriculum Assessment System (SCAS). No information was given on validity and reliability of these instruments.

From the students' questionnaires, it was found that a greater percentage of ISCS students than the non-ISCS students came from homes of higher socioeconomic class. This was reflected in parental vocations and education levels. Then, it was decided to use the paternal education level as a covariate in the treatment of the TAB Science Test scores because it was believed that there is a relationship between socioeconomic class and achievement. The TAB Science Test was originally developed by Butts and Jones (1966) to measure inquiry skills of students.

A combined TAB test of Form A and Form B was administered to all the subjects after approximately two-thirds of the school year had elapsed. The researchers said that a combined form of the TAB Science Test was more suitable for seventh-grade students. The scoring procedure for the TAB Science Test yielded a numerical score that reflected the inquiry behavior of the student. A possible maximum score was 565 and a minimum score was 0. The reliability calculated from the correlation between halves was .43. It may not be very reliable. Also, no validity was shown for the combined form of the TAB Science Test.

The paternal education level was used as a covariate, and each subject's I.Q. was used to block the subjects into cells for the ANCOVA technique. It was not appropriate to use each student as the unit of analysis in this study because the student was not individually, randomly sampled.
Data analysis showed no significant difference existed between the treatment groups, among three ability groups on the TAB Science Test scores. Also, no treatment x ability interaction effect existed on the TAB Science Test scores. In other words, these results failed to demonstrate the expected gains in inquiry skills on the part of the seventh grade ISCS students.

The researchers also compared the teacher behaviors of the two treatment groups. However, the percentage of time spent in each behavior category was quite similar. The ISCS teachers spent 43% of their time in observing but not responding to the students. The non-ISCS teachers spent 32% of their time in this category. Observation data showed that the ISCS teachers were moving about the classroom, observing and talking with small groups of students. However, the non-ISCS teachers spent most of the time talking to the entire class. The ISCS teachers spent 17.1% of their time in category 9 ("makes statements which tell the student what to do"), while the non-ISCS teachers spent 7.8% of their time in this category. Overall, the non-ISCS teachers spent 79.4% of their time with the entire class and 21.3% with the small groups. The ISCS teachers spent 80.2% of their time with the small groups and 19.7% of their time with the entire class. The ISCS teachers spent 8.1% of the time asking questions. Non-ISCS spent 9.6% of the time asking questions.

Based on the above comparisons of teacher behaviors, the researchers suggested that the similarity of the teachers' behaviors between the ISCS and non-ISCS teachers may possibly explain the insufficient progress on the TAB Test scores by the ISCS students.
The results indicated that ISCS students did not show a clear gain in inquiry skills. On the other hand, the ISCS and non-ISCS teachers exhibited similar classroom behaviors except that the ISCS teachers interacted more with small groups of students while the non-ISCS teachers interacted more with larger groups of students.

Raghubir (1979) compared the relative effects of either a (a) laboratory-investigative approach, or (b) lecture-laboratory approach in terms of cognitive factors and associated attitudes. In the laboratory-investigative approach, students began the study of a unit with laboratory investigations rather than a textbook assignment. In contrast, in the lecture-laboratory approach, the function of the lecture was to transmit factual information and material concerning laboratory exercises which would then illustrate the information presented in the lecture.

The experimental and control groups did have a pretest. But, the control group did not have a pretest on attitudes toward teaching methods. Twenty-six students were assigned to the experimental group and 28 students were assigned to the control group. A matching method was used to assign students to the experimental and control groups. The available matching variables included the Canadian Abilities Test-Level F, which was designed by Thorndike and Hagen to give an overall appraisal of the students' scholastic aptitude and abstract reasoning. No validity or the sources of the test were given. An estimate of reliability was .72 using KR-20. It should be noted that when the matching method was employed, the correlations between available matching variables and the dependent variable needed to be high in order to reduce sampling
errors (Borg & Gall, 1989). In this study, the correlations between matching variables and dependent variables were not indicated.

Pretests and posttests were given to the experimental group by using the Test of Academic Progress, which included a 50-item, multiple choice test prepared from the BSCS Yellow and Blue Versions, and a Comprehensive Final Examination designed to measure the cognitive factors. The researchers reported a reliability estimate of .68, and a validity estimate of .63. The type of validity was not reported. The experimental group was compared with the control group by measuring the cognitive factors of six tests. Each test had 25 multiple-choice items and was administered at the end of a four-week interval to evaluate student progress. The tests reported reliability estimates of .68-.72, and validity estimates of .70-.73. The experimental group was pretested and posttested to measure the specific associated attitudes using a Thurstone Scale developed by Downs. There are 26 items in this test; reliability was .74, and validity was .75. The control group was only posttested on this instrument. Reliability of this test was .69-.71. Validity was indicated to be .68-.69. The researcher mentioned that the test was given to the two groups at different times. Therefore, values of reliability and validity for experimental group and control group were calculated separately, and then indicated by a range of values.

Since the control group did not have the pretest, ANCOVA could not be used for the data analysis. Instead, a t-test was used. But, the degrees of freedom as well as the unit of analysis were not indicated. It was found that for the experimental group, there existed significant differences on the gains of cognitive factors between pretest and posttest and associated
attitudes. The experimental group performed significantly better than the control group on test items for the same cognitive factors, and associated attitudes.

The researcher concluded by stating that students using the Laboratory-Investigative approach acquired a greater understanding of science, greater information retention, and a better ability to think scientifically. But, the instrument used to measure students' attitudes toward the Laboratory-Investigative approach was not suitable for the control group because they lacked experience in this approach to learning.

Kyle et al. (1979) used a factorial design to investigate and analyze specific student behaviors in introductory and advanced level laboratories for five science disciplines: botany, chemistry, geology, physics and zoology. The researchers intent was to draw generalizations about students' behaviors in the laboratory across the five disciplines.

Three hundred and thirty-three student observations were collected from the five science disciplines by randomly selecting students from a given laboratory and recording their behaviors at three second intervals for ten minutes at a time. The same students may have been observed more than once during the seven week period of data collection. Further, ten-minute observations were made during the actual laboratory activity. Portions of the pre-lab and post-lab discussions were not included in the observation.

The Science Laboratory Interaction Categories (SLIC) was designed specifically for use in science laboratories and used to collect data in this study. There were nine categories of lesson-related behaviors (e.g.,
shows, experiments, transmits, questions, listens, observes, reads, writes, moves) and non-lesson related behaviors. The validity of SLIC was established and reported in a study by Kyle (1977). Reliability calculated by the Scott Coefficient (\( \mu \)) was .76 for all observers. The number of observers was not given.

The observation data indicated that there existed significant differences in the mean behavior score for E-experimenting, L-listens, O-observes, R-reads, W-writes notes or records data among the introductory and advanced level courses within the five science disciplines. A greater number of behavioral differences were also shown among the five disciplines as a whole: S-shows, E-experimenting, T-transmits information, L-listens, O-observes, R-reads, W-writes notes or records data, and M-moves around the room purposely.

The average amount of experimental time for all observed laboratories was 36% of the total class period. Since pre- and post-laboratory discussions were not coded, these percentages only reflected the "active" portions of the observed laboratories. The percentage of laboratory time in which students asked questions ranged from 1.5 to 2.7%. On the average, students asked questions only 2% of the time. Perhaps, this percentage reflects the students' use an alternative method for obtaining information in the laboratory. The percentage of laboratory time that students listened either to the instructor or other students ranged from 6.7 to 30.8% while students on the average listened 14.7% of the time. The researchers said that the students spent very little time listening to any of the students' questions or the instructor's questions. Students in the laboratories transmitted information either to the
instructor or to other students on the average of 5.8% of the time. Therefore, the researchers concluded that the nature of the laboratory activities was more directly related to confirming facts and theories and gathering correct scientific data, than the broader open-ended investigative approach which involves exploring, inquiry, testing and explaining. The students did not need to spend more time on transmitting information and the high percentage of time spent writing and reading (26.8%) supported the above conclusion.

It should be noted that the sample for this study consisted of university level students. Therefore, the results of this study may not be generalizable to students at other grade levels. Further, the criterion for stating the percentage of time use for each specific behavior may need more evidence by follow-up investigation.

Ivins and Markle (1989) attempted to determine if typical textbook laboratory exercises could improve achievement and retention if they were used to introduce new information. This was a nonequivalent control group design. The difference between the experimental and control groups in the study was the sequence of laboratory activities in the lesson. The experimental group experienced the laboratory exercises at the beginning of the unit while the control group utilized the lab as a verification experience.

Forty-two ninth-grade biology students were selected as subjects for this study. The sampling assignment was not indicated. These students were from two classes which were evaluated as general level classes in their district. The subjects possessed Otis-Lennon Mental Ability Test Scores that ranged from 75 to 118. Two instruments were used for this
study. Form A was utilized for the pretest and delayed posttest while Form B was utilized for the posttest. Both tests yielded two scores, a relevant score and an incidental score. The relevant score was directly related to the content of the laboratory exercises, classroom discussions, and textbook readings, while the incidental score covered information brought up during classroom discussions and textbook readings but was unrelated to the laboratory exercises. The total test contained 40 items, 20 relevant and 20 incidental. However, the percentage of test items used specifically for assessment of laboratories, exercises, classroom discussions, and textbook readings was not known. Also, the number of test items directly related to laboratory exercises, as well as whether they were part of the relevant test, was not given. No data indicating validity or reliability of these tests were provided. The pretest was administered prior to instruction, the posttest immediately after instruction had been completed, and the delayed test was administered nine weeks after instruction had been completed. No classroom observations to validate instructional approaches were reported. It was not known whether the two groups were taught by the same teacher.

Multivariate analysis of covariance was employed with the posttest and the delayed test to compare the performance of students in both experimental and control groups. The covariates used were the pretest scores and the scores on a standardized test of student ability called the Scholastic Achievement Index (SAI).

The results of data analysis indicated that a significant difference existed on the delayed-test scores between the two groups. The mean scores for the experimental group was 40.6%, while it was 30.4% for the
control group. Only a significant difference on the delayed-relevant test score was found by conducting the follow-up univariate analysis of variance. This difference favored the experimental group. The researchers concluded that if the sequence of instruction was varied (laboratory instruction, textbook reading and classroom discussion), there may be no measurable difference in immediate test scores between the two groups, but that the scores of the relevant items on the delayed test were approximately 10% higher for students who experienced laboratory first. No significant difference on the delay-incidental test score was found. The researchers also pointed out that the characteristics of students, material to be learned, and quality of instruction may have influenced student learning.

Summary

These studies on laboratory teaching addressed the effects of the types of teaching and the nature of the tasks on students' behaviors and achievement. However, very few studies investigated student-student interactions within lab groups (Hofstein & Lunetta, 1982; Johnson, 1981). This is particularly significant because several studies involved students working together during the lab session. Therefore, the nature of the interactions among the students within the lab group should be investigated, particularly when an effect of such interactions on learning science might be expected. Perhaps the SLIC can be used to observe student behaviors while they are working within groups in science laboratory activities. However, the SLIC system (Kyle et al., 1979) may be
only valid for university level students and not for junior high students. Junior high students' behaviors, such as transmitting information and manipulative skills, are not comparable to university level students. Normally, the verbal ability of university students is better than junior high students. Also, the university students may have more experience working with experiments as well as working in groups with other students.

Studies with Laboratory and Cooperative Learning

Research studies of cooperative learning have rarely been conducted within science laboratory instruction. Above all, the measurement of the levels of cooperation within the group has never been considered. Without knowing the students' interactions within the group, the effect of laboratory instruction can not be appropriately evaluated. The review in this area focused on the teaching of activity-oriented laboratory investigations with a cooperative goal structure.

Johnson (1976) investigated student perceptions of competition or cooperation as determined by the type of science curriculum being used, and compared these perceptions to the preference of students for how they would like to interact.

All sixth-grade students (n = 108) in one elementary school were randomly assigned to one of the three treatment groups: textbook only (T), textbook supplemented with materials for "laboratory" experiences (TM), and laboratory only (L). Laboratory here meant inquiry-oriented activity.
The Lorge-Throndike Intelligence Test and the Stanford Achievement Test of Word Meaning and Paragraph Meaning Skills (Kelly & Thibaut, 1969) were used to assess the entry level of students. No information on validity or reliability was given. However, the students were reported as "average" level when compared to national norms.

The same textbook, Concepts in Science-6, unit on "Electrons in Action" was utilized during the six-week instructional period of the study by the T and TM groups. The unit on "Batteries and Bulbs" is a component of the science program (Elementary School Science) and was used by the L group. However, the equivalence of content between these two units was not compared or reported. It can be said that all three groups utilized newer science materials, but on a range of instructional modes from "traditional" (T) to laboratory inquiry (L), with an intermediate group combining textual presentations with completely inquiry-oriented laboratory materials (TM). One elementary teacher taught all of the groups.

No training program for teaching in the three treatments was discussed. Instead, the researcher mentioned that this teacher had 24 years of teaching experience and had previous background and experience with the material employed in the study. The researcher reported that the observations, videotaping and teacher’s daily instructional logs strongly suggested that the teacher was using three different teaching approaches with the three groups. But, no further details were given. During the sixth week of the study, 14 students per treatment group were randomly selected for individual interviews, making a total of 42 students. Ten to 15 minutes were needed to collect the
data from each student by using the instrument developed by Johnson (1973). This projective instrument consists of eight pairs of photographs depicting an aspect of cooperative or competitive classroom structure and a short story of two or three sentences describing in detail each of the pictured situations. This scale includes four Likert-type questions with five response options. The possible score for each item is 0 to 5. No information on the construction, validity and reliability of this instrument was reported. Each student was also asked to complete a short semantic differential scale which was used to examine the students' feelings about their science class. No information was given on the validity and reliability of the semantic differential scale.

Data analysis indicated that there were no significant differences in the way the three groups of students perceived the structure of school in general. However, the students' perceptions of the goal structure and their preference for goal structure were significantly different, with a small percentage (19%) of the students perceiving a cooperative structure and a large percentage (70%) of the students preferring a cooperative structure. There were significant differences between the groups in their perceptions of inquiry in science classes. But, no further data to indicate statistical difference among the groups of textbook only (T), inquiry-oriented laboratory and textbook (TM), and inquiry-oriented laboratory only (L) were evident. For the perception of students for goal structure in science class, there was a significant difference between the groups. One hundred percent of the students in the inquiry group perceived a cooperative goal structure; 86% of the mixed inquiry and textbook group perceived a cooperative structure; and 50% of the textbook-only group
perceived a cooperative structure. However, the comments from the groups showed some differences in perceptions of cooperation. In other words, a different kind of cooperation was perceived by those students who worked with just the textbook as compared to the students who were working with materials. For instance, students in the L and TM groups spoke of cooperation as "sharing ideas," "compare," "help each other," "better ideas," and "teacher lets us show each other," while the students in T group who perceived cooperation spoke of "she lets us discuss things," "compare answers," "teachers like to know what we are doing." It was obvious that "sharing ideas" and "helping each other" existed within the groups of L and TM, but not in the T group. On the semantic differential scales, there was a consistent relationship with the inquiry-oriented laboratory group (L) always closer to the positive end of the continuum, the mixed group (TM) next and the textbook group (T) least positive. However, significant differences existed only on the enjoyable-unenjoyable scale.

The data definitely supported the hypothesis that the inquiry oriented science classes were perceived by students to be more cooperative than the textbook classes; that all three groups of students had a preference for a cooperative science class; and that all groups perceived school as a competitive enterprise but would have preferred school to be more cooperative.

Humphreys et al. (1982) compared the effects of junior high school students' science achievement taught using cooperative, competitive, or individualistic approaches.
The subjects were 44 ninth-grade junior high school students. These students represented the middle range of academic ability and achievement as evidenced by national percentile ranks on standardized tests administered to ninth-graders by the school district. The upper and lower five percent of the students were not included in the study. The researchers apparently thought classroom teaching is most accurately assessed with students whose ability level falls between the top five percent and bottom five percent.

The duration of this study was six weeks. Two-week units on heat, sound and light, and nuclear energy were taught to all students. Each unit was built around laboratory activities, and taught by the same teacher. The researchers tried to decrease the systematic errors which may result from a teacher effect, and the use of different amounts of time by assigning the same teacher to teach the same unit to all three conditions. However, it is questionable whether the 44 students of the three conditions in three rooms could be taught effectively, at the same time by one teacher. It would be very difficult for a teacher to manage three classrooms simultaneously.

The independent variables were the three goal structures. Different reward structures for giving students grades were used in the different conditions. The students were evaluated on a norm referenced basis for the competitive condition, and a criterion referenced basis for both the cooperative and individualistic conditions. The researchers mentioned that the validation of conditions had been done by unscheduled and unannounced observations, no information of a systematic observation instrument was provided and no data was provided.
Students' achievement and students' attitudes toward their instructional experiences were the two dependent variables for this study. Five achievement tests were given to all students: pretest, three unit tests, and a retention-review test. No validities or reliabilities were indicated except for the reliability (.86) of the retention-review test by using Hoyt's variation of KR-20. The researchers indicated that the items for unit tests measured factual recall of the content. Two questionnaire measures of students' attitudes toward cooperative, competitive, and individualistic instruction were used. The first was an adaptation of the three social interdependence scales developed by Johnson and Norem-Hebeisen (1979). The second attitude measure was a semantic-differential instrument using ten seven-point bipolar items. The ten bipolar scales on the semantic-differential questions were highly correlated with one another and they were summed together to obtain an overall evaluation of each goal structure. The scales were chosen to measure students' interest in the goal structure, and evaluation of the anxiety-producing quality of the goal structures. The reliability and validity were not indicated and the sources and construction of the semantic-differential instrument were unknown.

Twenty hours of training in teaching with the cooperative, competitive and individualistic conditions were given to three male teachers. Each teacher taught one of three units (heat, sound and light, nuclear energy) using one of three conditions. Also, during the first week of each new unit, the teachers gave a short questionnaire to their classes to ask for student perceptions of the conditions. The results of validating observations showed that the three teachers were 100% accurate in their
operationalizations for the three conditions. The student questionnaire results indicated that students accurately perceived their condition at an acceptable level of accuracy (87%). However, failure to show the validity and reliability of the observation instrument and questionnaire of student perceptions cause these results for the validation of the conditions to be questionable.

The data analysis of the posttests showed that students in the cooperative condition scored higher than did the students in the competitive and individualistic conditions, and students in the individualistic condition scored higher than did the students in the competitive condition. But, the unit of analysis used would not be correct unless each student was individually and randomly selected. On the retention test, students in the cooperative condition scored higher than the students in the competitive and individualistic conditions. The correlations between the posttest and retention-review test were significant in the cooperative and individualistic conditions, but not in the competitive condition. On the attitude scales and the semantic-differential measure, students in the cooperative condition evaluated their condition more positively than the students in the competitive and individualistic conditions, and students in the competitive condition evaluated their condition more positively than the students in the individualistic condition.

It was concluded that in both mastering and retaining the information being taught, having students work cooperatively has a more positive impact than does having students work competitively or individualistically.
Okebukola and Ogunniyi (1984) conducted a 3 x 3 factorial study to investigate the effects of cooperative, competitive, and individualistic science laboratory interaction patterns on students' achievement in science and the level of acquisition of practical skills. The first factor was the interaction patterns occurring at three levels (cooperative, competitive, and individualistic). The second factor was student ability which had three levels (high, average, low).

Subjects consisted of 1025 ninth-grade students from 12 randomly selected junior high schools. Twelve volunteer preservice science teachers participated. Achievement data was collected by using a 50-item multiple choice Science Achievement Test (SAT) referenced to topics in chemistry, biology, and physics on which the objectives for the lessons used in the study were based. The researchers reported that these items had survived the scrutiny of a five-man panel of judges from an initial pool of 92. Construct validity of the SAT was not given. But, a test-retest reliability of .83 for the final form of the SAT was reported, and the internal consistency was .89 using KR-21. Practical skills were measured by using the Science Practical Test (SPT). The SPT is a ten-item test requiring students to demonstrate behaviors such as formulating problems, controlling variables, making and reporting measurements, describing observations, making graphs, making tables, determining and preparing adequate dilutions, interpreting observed data, drawing conclusions, and predicting on the basis of experimental data. Nevertheless, the validity of the SPT was not reported. However, a test-retest reliability of .77 was indicated. In order to evaluate and record the scores for the behaviors gathered from SPT, the Practical Test
Assessment Inventory (PTAI) developed by Tamir, Nussinovitz, and Friedler (1982), was used to assess students' responses. The PTAI is a 21-category observation instrument designed to assess inquiring skills. The validity and reliability of the PTAI were not mentioned in this study.

Participating teachers were subjected to a rigorous 30-hour training regimen spanning a period of three weeks. The intent of the training was to equip the teachers with the necessary pedagogical skills for implementing the treatment conditions. But, preservice teachers may not adequately implement the intended conditions. A 10-category adaptation of an observation instrument developed by Peterson and Janicki (1979) was used to evaluate the expected behaviors of each treatment condition. An 85% level of observer agreement was reached after the training program. The interrater reliability during the period of study was not provided.

The student ability levels were trichotomized by conducting pretests based on practical skills (SPT/PTAI) and the SAT. In the cooperative and competitive conditions, four types of groupings were composed: three homogeneous groups (high, average, and low ability) and one heterogeneous group. Each group consisted of five members. In the individualistic condition, each student worked on his/her own. The researchers mentioned that 80-minute lessons were built around laboratory activities.

Knowing that the teachers were accurate in their operationalizations of the three conditions, the trained observers coded four randomly selected lessons taught by each participating teacher. The
observation categories were further subjected to a chi-square test of homogeneity. Treatment differences were confirmed.

The results indicated that a significant interaction effect existed between the three interaction patterns and ability levels. Although the two main effects cannot be separately determined, the researchers reported that two significant main effects existed among the goal structures and ability levels on the achievement data. The researchers reported that for the cognitive achievement measure, students in the cooperative group achieved better than those in the competitive group and those in the individual group. No significant differences existed between the competitive and individualistic groups on achievement measures. The findings also revealed that the high ability cooperative group students performed best, and the low ability competitive group students the least. The high ability individualistic students did not differ significantly in achievement from the high ability competitive group students.

For the laboratory and practical skills, the competitive group showed the best competence. The performance of students in the competitive group was better than those in the cooperative group. The cooperative group students exhibited better practical skills than the individualistic students. As for the mixed ability (two high ability, two low ability, and one of average ability) group, the students in the cooperative group were superior to the competitive group students in cognitive achievement. But, the competitive group was found to be superior to the cooperative group in the level of acquisition of practical skills. Overall, the high ability group performed best, followed by the mixed ability group on the achievement posttest scores of students in the cooperative condition. The low ability
group exhibited the poorest performance. The same pattern of result existed in the competitive condition. For the practical test scores, the high ability group in both the cooperative and competitive conditions was found to be superior to the others with the mixed ability group coming in a close second.

The cooperative group was found to be superior on the achievement measure with no difference between the competitive and individualistic groups. The competitive group outperformed the others in practical skills. Further, mixed ability cooperative groups did significantly better than the mixed ability competitive groups in achievement but not in practical skills. But, it is inappropriate to conduct follow-up comparisons of main effects when interaction effects exist.

Okebukola (1986b) used a pretest-posttest control group design to examine the differences in attitude toward laboratory work between students in a learning environment that was structured cooperatively and students in an environment that was not so structured. Gender differences between experimental and control group students with respect to attitude toward laboratory work was also investigated. Experimental and control group subjects were ninth grade biology students. The experimental sample (n = 113) consisted of 58 males and 55 females. The control sample (n = 110) was composed of 52 males and 58 females.

The 62-item, five-option, Likert-type Attitude to Laboratory Work Scale (ALWS) developed and validated by Hofstein et al. (1976) was chosen to measure students' attitudes toward laboratory work. However, after reviewing the study of Hofstein et al., the validity for ALWS was not described. Further, the original scale was constructed for a chemistry
laboratory. In this study, chemistry laboratory was modified to read "biology laboratory." There may be some differences between chemistry laboratory and biology laboratory. Face validity may be satisfied, but the establishment of content validity may be questionable. A Cronbach alpha reliability of .87 was computed for the scale in an earlier field trial.

One preservice biology teacher who had experience in the use of cooperative learning served as the experimental group teacher. One regular biology teacher served as the control group teacher. This assignment may cause confounding of teacher effect and treatment. The experimental group teacher was subjected to a training program which was designed to equip him with the necessary pedagogical skills for implementing the cooperative learning strategy in the science laboratory. At the end of the intensive training exercise, a two person observation team, using an observation instrument modified after Peterson and Janicki (1979) confirmed that the experimental teacher could implement the treatment correctly. The interrater reliability was .93.

ALWS was administered to the experimental and control group subjects twice, a pretest and posttest. Experimental subjects were organized into four-member, heterogeneous ability groups made up of one high ability, one low ability and two medium ability students. Each group had two male and two female members. Subjects in the control group were not grouped but worked as whole classes. The control group students did not have any opportunity to work cooperatively together but had an opportunity to participate in laboratory activities. All the practical lessons were instructed by teacher demonstration. In this case, it was obvious that the students in the experimental group may have more
opportunity to do "hands-on" laboratory activities as well as working together within their groups. The treatment lasted for six weeks. Both experimental and control classes had identical lesson topics on nutrition in animals and plants.

It was found that experimental group subjects had a significantly more favorable attitude toward laboratory work in comparison with subjects in the control group. Male students favored laboratory work more than their female counterparts. The male and female subjects in the experimental group had substantially greater means than their control group counterparts. The findings of this study supported the idea that cooperative learning assisted students in developing favorable attitudes toward laboratory work.

**Summary**

Even though several studies have tried to apply the cooperative learning strategy to laboratory oriented situations, there was no research conducted to investigate the important variable of levels of group cooperation during the laboratory activity. Therefore, a study designed to examine the effect of different levels/quality of cooperation on students' achievement during laboratory instruction may be useful to both science teaching and science education research.
Survey of Observation Instruments Used in Laboratory and/or Cooperative Studies

A survey of six available classroom observation instruments was conducted in an effort to identify an instrument which includes those variables relevant to science laboratory activities which are conducted in a cooperative manner. The ultimate goal was to find an observation instrument sensitive to the levels of cooperation within lab groups.

Okebukola (1986b) used one systematic instrument which was originally developed by Peterson and Janicki (1979) to validate the treatments in four research studies (Okebukola, 1985, 1986a, 1986b; Okebukola & Ogunniyi, 1984). This instrument was originally used to compare the teaching between a small-group approach and large-group (whole class) approach. Eleven categories were included: Class as whole group, Class in small group, Student explains to whole group, Student explains in small group, Student receives student explanation in small group, Student asks question of student in small group, Student listens/observes in whole group, Student works quietly in whole group, Student works quietly in small group, Student off task in whole group, Student off task in small group. This instrument was originally constructed to assess the fidelity of implementation of the two teaching approaches (small-group approach versus large-group approach) and measure student behavior during class. This instrument is not appropriate for use in laboratory activities which are taught with a cooperative goal structure. Specifically, exact operational definitions of individual students' cooperative behaviors (social skills) in small groups
is needed if small group cooperation is to be investigated. This instrument only focuses largely on global group behaviors.

The Science Laboratory Interaction Categories (SLIC) was designed specifically for use in science laboratories and used to collect data at the university level. There were nine categories of lesson-related behaviors (e.g., shows, experiments, transmits, questions, listens, observes, reads, writes, moves) and one non-lesson related behavior. The validity of SLIC was established and reported in a study by Kyle (1977). Reliability calculated by the Scott Coefficient (II) was .76 for all observers. Kyle pointed out that the percentage of laboratory time in which students asked questions ranged from 1.5 to 2.7%. On the average, students asked questions only 2% of the time. The percentage of laboratory time that students listened either to the instructor or other students ranged from 6.7 to 30.8% while students on the average listened 14.7% of the time. The researchers said that the students spent very little time listening to any of the other students' questions or the instructor's questions. Students in the laboratories transmitted information either to the instructor or to other students on the average of 5.8% of the time. When taking these low percentages of several observed behaviors into account, it may not be useful to distinguish and categorize student interaction behaviors such as asking questions, transmitting information, conveying ideas, answering questions, and listening. Conversely, a generic term "discussion" may be more appropriate to represent these interaction behaviors (Johnson & Johnson, 1987; Yager, 1985). This instrument was originally designed to observe university students' behaviors in laboratory activities. The social skills exhibited during the lab were also not included. Therefore, it is
inappropriate to be used for assessing cooperative activities. Further, the validity of using this instrument at the secondary level is questionable because it was originally designed to observe university students' behaviors.

Yager (1985) compared the use of structured and unstructured student discussions during a series of cooperatively organized junior high map lessons. The checklist which was modified by Yager contains ten expected behaviors for the students working in groups. These behaviors are: summarizes, asks probing questions, paraphrases, gives direction to group's work, coordinates member's effort, expresses support, acceptance, expresses warmth, liking, contributes ideas, encourages others to contribute, and asks leader to restate information. No data on validity and reliability was reported. Also, no quantitative results were reported to demonstrate that the student behaviors occurred in both discussion conditions (structured oral discussion and unstructured oral discussion). But, Yager stated that the structured condition appeared more active with all group members involved with the group work. The structured discussion also demonstrated more individual accountability than did the nonstructured condition. Only oral discussion behaviors were emphasized in Yager's study. However, students' behaviors in a laboratory which is taught in a cooperative manner would involve more than these behaviors. Collaborative behaviors in this study consisted of social skills and investigative skills. Social skills focus on the students' behaviors which can increase the effectiveness of group cooperation interaction (Association for Supervision and Curriculum Development, 1990). However, investigative skills concern the science laboratory skills
which are often used by students to conduct an investigation during a laboratory base instruction. Social skills, as well as investigative skills, should be included in an instrument if the students' group cooperation is to be measured.

Shymansky and Matthews (1974) used Matthews' Science Curriculum Assessment System (SCAS) - Teacher Behaviors and Student Behaviors, to investigate the effects of "student structured learning in science" (SSLS) and "teacher structured learning in science" (TSLS) instructional strategies on the behavior of 52 students in two fifth grade science classes at the Florida State University School.

Ten student behavior categories were: Miscellaneous (L0), Observe teacher (L1), Follows teacher directions (L2), Invents own activity (L3), Responds to teacher question (L4), Initiates interaction with teacher (L5), Initiates interaction with student (L6), Receives ideas from student (L7), Copies other student (L8), Gives ideas to other student (L9). Information on validity and reliability of SCAS system was not mentioned.

Four of the ten behaviors could be used to indicate some student-student interactions happening during science classes, such as: Initiates interaction with student (L6), Receives ideas from another student (L7), Copies from other student (L8), and Gives ideas to other student (L9). However, it is incomplete to observe students' behaviors in the laboratory by using this instrument. The applicable instrument should also include students' manipulative skills in addition to cooperative behaviors (social skills).

In a study conducted by Hall, Howe, Merkel, and Lederman (1986), the observation instrument was an adaptation of an instrument developed
by Stanback (1981). The instrument consisted of eight behaviors classified into three broad categories: Active learning- experimenting, observing, preparing/returning, discussion; Passive learning-reading/writing; Nonattending- conversing, disengaged. Both the active learning and passive learning behaviors are often observable in the science laboratory. This instrument is almost appropriate to observe students' investigative skills in the laboratory. If the cooperative behaviors (social skills) were added to this instrument, then the levels of cooperation within the group could be measured.

Verbal (spoken) interaction of students was measured by the Verbal Interaction Measure developed by Petersen (1985) in cooperation with the Cooperative Learning Center staff (Johnson, Johnson, Petersen, & Stanne, 1984; Lyons, 1982). The Verbal Interaction Measure enables the observer to code the direction of the verbalization by recording who is speaking, who is spoken to, and what is said. The verbal interactions are divided into four broad categories: task mode, management mode, social mode, and process mode. Each mode is further subdivided into eight categories: information, question, agreement, elaboration, disagreement, reading, praise, and miscellaneous. Again, the discrimination of four modes as well as eight categories for each mode is too "finely tuned." For example, "agreement" and "praise" can be blocked into the "encouraging" behavior when group cooperation is observed. Further, the investigative skills which the students need to conduct a laboratory activity are not included in this instrument.
Summary

A survey of the literature shows that several instruments for observing students' behaviors in the science classroom are available, but none consider the students' cooperation within the group. Development of an observation instrument which is appropriate for laboratory activities as well as sensitive to quality/quantity of cooperative interactions is necessary.

Critical Criteria for the Development of a Classroom Observation Instrument

In the research on cooperative learning, very few studies have assessed the integrity of treatment implementation. Additionally, no existing systematic observation instrument exists to fulfill such a purpose. Without knowing the quality of group cooperation, how can we truly assess student's learning in a cooperative learning condition? Unfortunately, no current observation instrument can be used to measure the levels of cooperation within a group in the science laboratory activity. A review of the literature on role interdependence, goal interdependence, social skills and role assignment in cooperative learning, and students' behaviors in the activity-oriented laboratory provides a foundation for the development of an instrument which can be used to observe the quality of group cooperation in science laboratory instruction when a cooperative learning strategy is applied.
Positive Role Interdependence and Role Assignment

Johnson and Johnson (1987) proposed that positive role interdependence exists when each member is assigned complementary and interconnected roles. Group cooperation can be increased by assigning roles to each member of the group. They suggest roles such as: recorder to write down the group's answers or edit the group's report; an encourager to make sure every one in the group understands what is being agreed on; and an observer to keep track of how well the team members are collaborating. Usually the roles are rotated for different learning activities so that each student obtains considerable experience in each role. They further suggest roles which include summarizer-checker, researcher-runer, recorder, encourager, and observer which are more appropriate for a science lesson. Also, assigning such roles is an effective method of teaching students collaborative behaviors.

Additionally, Collette and Chiappetta (1984) agreed with the views of Seymour and Padberg (1975) concerning the positive effects of using roles during group work in the science classroom. The Inquiry Role Approach (IRA) organizes students into teams of four. Each student is given one of the following roles: coordinator, technical advisor, data recorder, and process evaluator. Students change roles as they work on different investigations. Collette and Chiappetta further state that many laboratories can best be handled in groups. This is especially true for middle school students. Collette and Chiappetta suggest the assignment of five roles during laboratory work: (1) Coordinator: keeps the group on task and working productively, (2) Manager: gathers, maintains and
returns equipment and materials, (3) **Investigator**: conducts the investigation, (4) **Recorder**: records the data and keeps notes on the investigation, (5) **Reporter**: organizes and reports the findings.

**Social Skills and Investigative Skills**

An instrument designed for the observation of students working together within cooperative learning groups in a science laboratory must include both social and investigative skills. The available observation instruments only focus on one of these categories of variables and ignore the other. A valid observation instrument for students' collaborative behaviors should include both investigative skills and social skills.

Johnson and Johnson (1987) stated that cooperative learning requires that students appropriately use interpersonal and small-group skills. Students must be taught the social skills needed for collaboration, and they must be motivated to use them. The interaction pattern in a cooperative learning condition may be observed to include prolonged and intense interaction among students, helping and sharing, oral rehearsal of material being studied, peer tutoring, and general support and encouragement. Johnson and Johnson (1987) have listed a number of positive behaviors which can indicate students' participation pattern: contributing ideas; asking questions; expressing feelings; active listening; expressing support and acceptance (toward ideas); expressing warmth and liking (toward group members and group); encouraging all members to participate; summarizing; checking for understanding; relieving tension by joking; and giving direction to group work.
Teachers need to define cooperation operationally by specifying the behaviors that are appropriate and desirable within the learning groups. These behaviors might include staying with your group and not wandering around the room; use of quiet voices; taking turns; everyone participating; mistakes are okay; staying on task; trying ideas; listening carefully to others; asking others for help; checking with the teacher only when all team members do not understand; encouraging your partner (put-downs are not allowed); using each other's names (Cantlon, 1989; Johnson & Johnson, 1987).

A social skills identification worksheet which has been used to train students' collaborative behaviors contains 21 behaviors (Association for Supervision and Curriculum Development, 1990): moving desks into place; sitting face-to-face; talking in quiet voices; distributing materials; sharing materials; monitoring time; listening; contributing ideas; taking turns; praising others; encouraging participation; checking for understanding; asking for explanations; criticizing ideas, not the person; joking to relieve tension; paraphrasing; summarizing; challenging ideas; reaching consensus; taking different perspectives.

The social skills listed above appear to be a comprehensive list of students' behaviors while working within a cooperative learning group. Listening; taking turns; praising others; encouraging participation can be combined as "encouraging behaviors." Contributing ideas; asking for explanations; criticizing ideas, not the person; taking different perspectives; challenging ideas; reaching consensus; paraphrasing and summarizing can be considered as "discussing behaviors." Therefore,
these 21 behaviors can be collapsed into two social skills such as discussing and encouraging for inclusion in an observation instrument.

On the other hand, there are several investigative skills which are needed for the students to conduct the laboratory activities such as: managing, observing, manipulating, reading, writing, and reporting.

Summary

For laboratory activities which are instructed with a cooperative goal structure, both social skills and investigative skills should be contained in an observation instrument if it is to be used to measure the levels of cooperation within the group. Ten collaborative behaviors which consist of social skills, investigative skills and non-learning behaviors were included in the observation instrument, will be discussed in Chapter III.

Summary of the Literature Review

In this chapter, the review of literature on the effects of cooperative learning in the science classroom seemed to present some optimistic findings. Unfortunately, student-student interactions were not examined in relation to the effects of applying a cooperative learning strategy in a laboratory condition. Since students are very often assigned to groups during laboratory activities, students' behaviors within the group should be investigated. Further, without consideration of the levels of cooperation within a group, the discrepancy between intended conditions and actual classroom practice can not be known. Also, to what degree
cooperation must exist for it to be a useful instructional approach can not be determined without focusing on students' patterns of interaction. Prior research provides no information in this regard.

On the other hand, positive interdependence of students' is assumed to be increased by assigning students different roles within the group (Association for Supervision and Curriculum Development, 1990; Cantlon, 1989; Johnson & Johnson, 1987; Johnson, Johnson, Holubec, & Roy, 1988). But, no evidence supporting this belief has been produced by previous research. In order to more deeply understand the dynamics of the cooperative learning strategy, the specific levels of cooperation within the group should be measured. Unfortunately, no existing observation instrument can be used to pursue this goal. An observation instrument of this kind should include both social skills and investigative skills which students tend to demonstrate during science laboratory activities which are cooperatively structured.
Chapter III

Design and Method

Introduction

Physical science laboratory activities were chosen to investigate the effects of differing levels of group cooperation on students' learning in the science laboratory. In order to make sure the selected schools could provide students enough apparatus to conduct an investigative laboratory, visits to schools were essential prior to selection. Six intact classes were invited to participate in this study.

For these six classes, the teaching materials, assignments and teacher-made quizzes/examinations were checked for similarity and validity. The difference on the students' achievement within each of the different learning conditions were computed within each of the six classes as well as between classes which were instructed by the same teacher. There were three instructional approaches, each approach is also referred to as a treatment in this study.

Subjects

The sample for this study consisted of six intact classes of seventh grade physical science taught by two teachers, with each teacher instructing three classes. A total of 141 students was selected from two middle schools in Linn and Benton County. School "A" is located in a
university town and it serves 565 students. Students' as well as parents'
expectations of education are generally high. School "B" has 636
students, and is located in a middle class, suburban environment. Most
of the students are from working class families and education is not a
high priority. The two teachers are familiar with the cooperative
learning strategy and are experienced in the implementation of the
desired instructional approaches for laboratory activities. Teacher A has
one year of fifth grade and six years of seventh and eighth grade teaching
experience, including physical science, earth science, and life science.
Teacher B has nine years of teaching experience in fifth grade and seven
years of experience in grades 7-8 science, math, physical and earth
science.

\textbf{Procedures}

Students were randomly assigned to groups of three in each class
and stratified on the basis of achievement and gender. Teacher B was
concerned that female students might not learn well in groups consisting
of two males and one female. Consequently, in the classes of teacher "B,"
most groups were homogeneous with respect to gender. Validity for such
a concern has been supported by Webb (1984) who reported that in male
dominated groups, girls were less successful than boys in obtaining
answers to their questions. In summary, two of the six classes were
randomly assigned to the "traditional" approach with each teacher
instructing one of these classes. These students worked in learning
groups in which competitive or individualistic student-student
interactions commonly exist. The other four classes followed a cooperative goal structure. But, students in two of these four classes worked in groups with role assignments. Students in the other two classes worked in groups without assigned roles for group members.

For the role-assignment group, each student was assigned a specific role. These roles were rotated for each laboratory activity. Students in the non-role assignment cooperative learning condition were not assigned roles. It is usually not a good idea to put two or three different approaches such as: traditional learning groups and cooperative learning groups in the same class because of the wide difference in the goal structures and requirements for goal achievement for students in these conditions. In particular, individual lab reports were completed by students learning in the "traditional" learning condition while a group report was submitted by the students learning in the cooperative conditions.

Each student stayed in the same group throughout the study, but the students in the cooperative learning groups with role assignments switched roles for each laboratory activity. Three roles (manager, investigator and recorder) were used in the role assignment approach. Each student was assigned a role at the beginning of the practice observation period. The mnemonic "RIM" was used to help students remember their roles when they needed to switch roles. For instance, The recorder (R) would change to investigator (I), the investigator (I) would change to manager (M) for the second laboratory activity and the manager (M) would change to recorder (R). This arrangement was necessary to meet one of the purposes of assigning roles, which is purported to guarantee students' equal involvement. The assignment of
classes and lab groups to instructional approaches is summarized in Table 1.

Table 1

**Summary of Class and Group Assignment to Instructional Approaches**

<table>
<thead>
<tr>
<th></th>
<th>Teacher A</th>
<th>Teacher B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>8 cooperative (with no role assigned) lab groups</td>
<td>8 lab groups &quot;traditional&quot;</td>
</tr>
<tr>
<td>Class 2</td>
<td>7 lab groups &quot;traditional&quot;</td>
<td>8 cooperative (with role assignment) lab groups</td>
</tr>
<tr>
<td>Class 3</td>
<td>9 cooperative (with role assignment) lab groups</td>
<td>6 cooperative (with no role assigned) lab groups</td>
</tr>
</tbody>
</table>

This scheme provided 46 lab groups. There were several groups consisting of two or four students (as opposed to the desired three) because all class enrollments were not divisible by three. Table 2 provides specific information on group composition.
Table 2

Group Composition, Number of Students in Each Instructional Approach

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Approach</th>
<th>Males</th>
<th>Females</th>
<th>Gender</th>
<th>No. of group</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Traditional</td>
<td>12</td>
<td>10</td>
<td>M</td>
<td>3</td>
<td>6 groups of 3</td>
</tr>
<tr>
<td>A</td>
<td>Non-Role Assignment</td>
<td>7</td>
<td>18</td>
<td>F</td>
<td>2</td>
<td>1 group of 4 (M)</td>
</tr>
<tr>
<td></td>
<td>Role Assignment</td>
<td>13</td>
<td>13</td>
<td>B</td>
<td>4</td>
<td>8 groups of 3</td>
</tr>
<tr>
<td>B</td>
<td>Traditional</td>
<td>16</td>
<td>10</td>
<td>M</td>
<td>4</td>
<td>6 groups of 3</td>
</tr>
<tr>
<td></td>
<td>Non-Role Assignment</td>
<td>9</td>
<td>10</td>
<td>F</td>
<td>2</td>
<td>5 groups of 3</td>
</tr>
<tr>
<td></td>
<td>Role Assignment</td>
<td>9</td>
<td>14</td>
<td>B</td>
<td>3</td>
<td>7 groups of 3</td>
</tr>
</tbody>
</table>

M = All male groups  
F = All female groups  
B = Mixed gender groups

When meeting the teacher, laboratory instructional materials, structuring a cooperative learning condition, and the purpose of this study were discussed and explained. The learning materials in the three different instructional approaches (with the same teacher) were held
constant. The teachers were asked to provide lab group worksheets as well as unit test papers. The teachers and the researcher also discussed the format of lab worksheets. The students in the cooperative learning conditions had three laboratory activities during which to familiarize themselves with the goal structure. However, in order to balance the effect of extra laboratory activities, the same activities were also arranged for the traditional classes. Then, formal observation assessing the levels of cooperation within groups were conducted. Each group was observed for five minutes during each observation period. Each group was also observed at least four times during the study.

The class periods of school A are 45 minutes, however, 41 minutes for school B. On the laboratory days, the teachers typically spent 15 to 20 minutes introducing and discussing the content of the laboratory activity. Classroom management and regular classroom routines such as announcements and collecting or passing back papers also took some time. Consequently, the students' allotted time for the investigative activity was about 20 to 25 minutes per observation period. Therefore, in order to have at least four observations for each laboratory group, each teacher provided seven laboratory activities. Teacher A provided (1) Building hot rods; (2) Speed Lab #1: Inclined planes; (3) Speed Lab #2: Inclined planes with different angles; (4) Density Lab #1: Density of water; (5) Density Lab #2: Densities of different objects; (6) Density Lab #3: Density of floating materials & liquids; (7) Pressure. Teacher B provided the following laboratory activities: (1) Center of gravity; (2) Archimedes' principle; (3) Pressure; (4) Work; (5) Inclined plane; (6) Pendulums; (7) Speed and acceleration.
Teacher B normally spent two periods completing each laboratory activity including manipulation and answering of questions. A handout was prepared for each laboratory activity. Students took data on the first day; however, most of the time the second day was used to answer the questions and complete the laboratory worksheet. Students often did not turn in the lab reports until the following day. On the other hand, teacher A wrote the investigative procedures including data collection, graphs, and questions to be answered on the chalkboard or overhead transparencies. Only Lab #2, and #7 were provided by worksheets. In addition, teacher A did not separate investigative activities into two major parts such as manipulation and the answering of questions. He allowed students to conduct their investigations and answer the questions until they finished the worksheet. There were several completion baskets at the back of the classroom for the different classes. When students completed their worksheets, they put their worksheets in the basket immediately. Most students turned in their worksheets on the same day.

The overall grades on homework assignments, activities, lab assignments (e.g., lab reports, worksheets) and scores on teacher-made lab quizzes/test before the study (referred to as students' beginning achievement) were used to insure that students were placed in groups which were heterogeneous with respect to achievement. The grades on lab assignments, worksheets and lab quizzes/test during the study were used to compute the students' achievement in relation to levels of group cooperation. The same panel used for establishing the content validity of the observation instrument was also asked to establish content validity for each lab quiz (one unit test provided by teacher A, two tests by teacher B).
The selection of test items of each lab quiz was based on the objectives of instruction and the content of investigative activities. Again, an agreement of 80% was the criterion for establishing the content validity of lab quizzes by the same panel of conducting the content validity of observation instrument. The number of groups was used as the unit of analysis for the data analysis.

**Development of Observation Instrument**

A review of several current observation instruments indicated a necessity for designing an observation instrument to measure the levels of cooperation within the laboratory group. A classroom observation instrument was developed which included social skills as well as investigative skills.

**Collaborative Behaviors**

The review of literature indicated that no current observation instrument is appropriate to observe students' behaviors during a lab activity which is taught using a cooperative goal structure. Ten collaborative behaviors (which consist of two social skills and six investigative skills) as well as two non-learning behaviors were included in the observation instrument.
Social skills:

**Discussing**- teammates' verbal interaction patterns during the investigative activity such as: communicating; answering questions; making an explanation or listening to others; asking questions and making suggestions; giving directions; confirming other members' ideas or opinions; checking for understanding, paraphrasing.

**Encouraging**- smiles, nods, listening with eye contact, supporting, and praising; encouraging participation.

Investigative skills:

**Managing**- gathering, arranging, preparing and returning equipment/materials for an investigative activity.

**Manipulating**- manipulating equipment, experimenting and data collection.

**Observing**- watching the investigative process.

**Reading**- reading of textbook, lab manual, and resources to complete the activity.

**Reporting**- reporting the results to the class; responding to the teacher; answering questions from teacher or students of other groups.

**Writing**- taking notes, writing, computing, making a graph, analyzing data.

Non-learning behaviors:

**Waiting**- waiting for the teacher's attention, or to gather equipment.
**Off-task** - talking about subjects unrelated to task; daydreaming; temporary inactivity; manipulating materials but not in a manner related to the assigned laboratory activity.

**Observation Instrument**

The Classroom Observation Instrument in Science Laboratory Activity (COISLA) includes investigative skills (i.e., managing, manipulating, observing, reading, writing, and reporting), social skills (i.e., discussing, encouraging) and non-learning behaviors (i.e., waiting, off-task) and was used to measure levels of group cooperation. The frequency of students' behaviors was recorded by tallies.

Figures 4 and 5 present two kinds of observation sheets: one for role assignment groups and the other for both non-role assignment and traditional groups.

**Validity and Reliability of the Observation Instrument**

The content validity of the classroom observation instrument was obtained using a panel of five members including three professors in the Department of Science, Mathematics and Computer Science Education at Oregon State University and two middle school science teachers. An agreement level of 80% on each collaborative behavior included in the instrument was the criterion for establishing content validity. If 80% agreement was not reached for a particular behavior, a modification or revision for that behavior was made and subsequent agreement were
<table>
<thead>
<tr>
<th>Date</th>
<th>Group</th>
<th>Period</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Topic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Roles**

Manager (M)  
Investigator (I)  
Recorder (R)  

**Student's name**

<table>
<thead>
<tr>
<th>members behaviors</th>
<th>M</th>
<th>I</th>
<th>R</th>
<th>M</th>
<th>I</th>
<th>R</th>
<th>M</th>
<th>I</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>manipulating</td>
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<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>discussing</td>
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<td></td>
</tr>
<tr>
<td>encouraging</td>
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<td></td>
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</tr>
<tr>
<td>off-task</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4. Observation Sheet for Role Assignment Group**
<table>
<thead>
<tr>
<th>Date</th>
<th>Group</th>
<th>Period</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Topic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Student's name**

(1) 

**Members**

(2) 

(3) 

<table>
<thead>
<tr>
<th>members</th>
<th>behaviors</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>2</th>
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</thead>
<tbody>
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<td>off-task</td>
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</tr>
</tbody>
</table>

Figure 5. Observation Sheet for Non-Role Assignment Group and Traditional Group
pursued. The categories of helping and summarizing behaviors were deleted from the original observation instrument for two reasons. First, helping behavior can be represented by other behaviors. For instance, if two students were working together to manipulate equipment, each student would be marked a tally on this particular behavior. Second, summarizing behavior was included in "discussing" behavior. In addition, non-learning behaviors were added after the three week practice observation period. It was expected that a broader spectrum of observation could be obtained when these two non-learning behaviors were included.

The investigator in this study was the only person to observe in the classroom. Therefore, inter-rater agreement was not necessary.

Classroom Observation

To insure that instructional conditions were correctly and appropriately implemented, the investigator observed the student groups in each class during a laboratory activity prior to the formal collection of data. Every group was observed for five minutes during each of seven laboratory activities. In order to observe students' behavior in different portions of the investigative activity, the observation sequence of groups was rotated for each class period. For example, the sequence of the group observations would be 1, 2, 3, 4, 5 the first time, 2, 3, 4, 5, 1 the second time, and so forth. The students were asked to wear name tags to help the observer recognize students. For the role assignment approach, name tags were also used to remind students of their roles. The observer used a small, battery-powered tape recorder which signaled, via earphone, 10
second intervals for observation followed by five seconds for recording of observations. Thus, behaviors were recorded four times per minute. The frequencies of collaborative behaviors were determined by marking the tallies in the appropriate boxes on the observation sheet.

**Practice of Observation**

The observer became familiar with the observation instrument and categories by observing students working together in physical science laboratories between March 27, 1991 and April 25, 1991. Practice observations were conducted to reinforce the appropriateness of the behavior categories. During this period, the students' behavior categorization was frequently discussed with the panel in order to establish the content validity of the observation instrument. The three weeks of "practice" also allowed students to become desensitized to the observer's presence. Further, the accurate categorization of students' behaviors was improved by clarifying the definitions of the ten specific collaborative behaviors.

**Data Collection**

Four observations of each lab group were originally planned to collect data on the students' collaborative behaviors in the three instructional approaches. Even though classroom observations had been scheduled before each class period, the pace of students' investigative activities could not be accurately predicted. Lehman (1990) also reported
that laboratory groups performing the same activity, used their laboratory
time quite differently. It was not uncommon to find that several groups of
students thought they had completed their work in a short period, while
other groups were still busy in their investigations. Further, the number
of laboratory groups in the "traditional" approach of teacher A and the
non-role assignment approach of teacher B were fewer than in the other
approaches. Therefore, several groups with these approaches were
observed five or six times. A total of 215 observations of the student lab
groups was conducted. On the average, each group was observed 4.7
times during the study.

In order to provide the cooperative learning group students with an
opportunity to familiarize themselves with the collaborative behaviors,
three "practice" activities were included. These familiarizing activities
also served as "practice" for the observer in the use of the instrument.

**Independent Variables**

The teacher and instructional approach were the two independent
variables in this study. Two teachers, with each teacher instructing three
classes were involved in this study. The three instructional approaches
included cooperative goal structure with role assignment, cooperative
goal structure without role assignment, and "traditional" (non-
cooperative) goal structure. In the role assignment approach, the
students learned under a condition of cooperative learning with a specific
role assigned to each group member. In the non-role assignment
approach, students were also taught using a cooperative goal structure,
but without specific role assigned to each member of the group. In the "traditional" approach, no specific roles were assigned to the group members as well as no group cooperation being encouraged during the laboratory activity.

**Dependent Variable**

Students' laboratory achievement was the dependent variable in this study. Students' laboratory achievement was assessed by grades on lab worksheets, lab reports and lab tests. These assessments were collected and compared among the three instructional approaches after completion of all observations to indicate the effect of levels of cooperation on students' achievement. For the "traditional" groups, the mean grade for worksheets, reports, etc. was used for comparisons with cooperative groups.

**Hypotheses**

The purpose of this study was to investigate the effect of cooperative learning on achievement in middle school physical science laboratory activities. The relationship between levels of cooperation within each laboratory group and achievement was assessed. The students' achievement in the different learning conditions, such as cooperative learning with role assignment, cooperative learning with non-role assignment, and traditional group learning, were compared in order to
assess the relative effects of different levels of group cooperation on achievement.

The differing levels of cooperation within each lab group were operationalized by the relative frequencies of collaborative behaviors observed in the groups during observations.

The following null hypotheses were tested:

**H₀ 1**: There is no significant difference in students' achievement among the three instructional approaches.

**Supplementary hypothesis**

**H₀ 2**: There is no significant difference in the frequency of a "particular collaborative behavior" within groups among instructional approaches as well as teachers.

For the testing of supplementary hypothesis **H₀ 2**, there were actually ten hypotheses, one for each of the ten observed collaborative behaviors.

**Data Analysis**

For the data analysis, the lab groups were used as the unit of analysis. The average occurrence of behaviors of group members per observation period (group means) across the study period were calculated for each group. The average group members' achievement prior to the observation period and final achievement were also calculated. Grades on lab assignments, reports and lab quizzes/tests of students who were taught by the same teacher were compared to indicate the effects of the different learning conditions within classes of a particular teacher. A
one-way ANCOVA was considered appropriate for testing the primary hypothesis ($H_0$ 1). Students' achievement and the relationships between students' achievement and the collaborative behaviors were analyzed using STATGRAPHICS, version 4.0 (Statistical Graphics Corporation, 1989).

For the testing of supplementary hypothesis $H_0$ 2, a two-way MANOVA was used to examine the differences in the frequencies of each of the ten observed collaborative behaviors in the three instructional approaches as well as two teachers by using SPSS/PC + Advanced Statistics™ V 2.0 (Norusis, 1988).
Chapter IV

Analysis of Data

Introduction

This study was undertaken to assess the effect of the level of group cooperation on students' achievement during a series of physical science laboratory activities in middle school. The results of analyses are organized into the following sections: (1) students' overall achievement prior to the study, (2) students' achievement at completion of the study, (3) students' collaborative behaviors, (4) the relationship between collaborative behaviors and students' achievement.

Students' Beginning Achievement

Students' beginning achievement was derived from mean performance on homework assignments, lab reports, worksheets, tests/quizzes, etc. In short, each student's percent score achieved in science prior to the study was calculated. Then, mean achievement scores for each laboratory group were calculated and class means were ultimately derived.

Table 3 presents a summary of students' achievement prior to the study. The number of groups (n), group means (X̄), standard deviation (SD), and standard error (SE) for each class are provided.
### Table 3

**Descriptive Statistics for Students' Beginning Achievement**

<table>
<thead>
<tr>
<th></th>
<th>Teacher</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{x}$</td>
<td>89.10</td>
<td>68.03</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>2.86</td>
<td>4.37</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.08</td>
<td>1.55</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>8</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Non-role</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{x}$</td>
<td>83.46</td>
<td>55.03</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>3.44</td>
<td>7.90</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.22</td>
<td>3.23</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>9</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Role</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{x}$</td>
<td>87.18</td>
<td>74.32</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>4.21</td>
<td>10.36</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.40</td>
<td>3.66</td>
<td></td>
</tr>
</tbody>
</table>

**Students' Final Achievement**

The students' final achievement scores were derived from grades on lab reports and tests. Teacher A provided scores from seven lab reports and one test. Teacher B provided scores from seven lab reports and two tests. Assignments and tests used to determine achievement were only those specifically related to laboratory activities. Consequently, the final
achievement scores used for this investigation may vary slightly from students' overall grade reports. Grades derived from assignments, tests, etc. which were not correlated to the special content of laboratory activities were not included. The scores of test items which were considered as unrelated to laboratory activities were not included in the students' achievement scores.

During the formal observation period (April 29, 1991 through May 22, 1991 for the classes of teacher A; May 1, 1991 through June 6, 1991 for the classes of teacher B), several students were periodically absent. For example, one student in the "traditional" class of teacher A only appeared on the first day, then she was absent because of illness for the rest of the study period. Table 4 presents a summary of students' attendance records. The total number of absences in the classes of teacher A was 40, as compared with 52 absences in the classes of teacher B.

Teacher A gave a test related to the contents of the seven labs on May 30, 1991. Teacher B gave two tests, one on May 23 and a second on June 11.

Table 4
The Frequency of Students' Absences During the Formal Observation Period

<table>
<thead>
<tr>
<th></th>
<th>Teacher A</th>
<th>Teacher B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>Non-role</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Role</td>
<td>19</td>
<td>17</td>
</tr>
</tbody>
</table>
Table 5 presents students' overall achievement after the study. The number of groups (n), group means (\(\bar{x}\)), standard deviation (SD), and standard error (SE) for each instructional approach is also provided.

Table 5
Descriptive Statistics for Students' Final Achievement

<table>
<thead>
<tr>
<th>Teacher</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Traditional</td>
<td>(\bar{x})</td>
<td>82.03</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>5.06</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>1.91</td>
</tr>
<tr>
<td>n</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Non-role</td>
<td>(\bar{x})</td>
<td>81.39</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>8.43</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>2.98</td>
</tr>
<tr>
<td>n</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Role</td>
<td>(\bar{x})</td>
<td>83.92</td>
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<tr>
<td></td>
<td>SD</td>
<td>5.86</td>
</tr>
<tr>
<td></td>
<td>SE</td>
<td>1.95</td>
</tr>
</tbody>
</table>

Table 6 provides within class comparisons of students' final achievement for teacher A. The students' initial achievement was included as a covariate and is listed as "pretest" in the data table. The ANCOVA technique was used to adjust students' final scores based on
their initial differences on pretest scores. Interestingly, the effect of the covariate was not significant, \( F (1, 20) = 3.56, p > .05 \). Further, there was no significant effect associated with instructional approach on the students' achievement, \( F (2, 20) = 0.64, p > .05 \). It is important to note that analyses related to students' achievement were made among the classes within teachers as opposed to between teachers. Since the teachers gave different tests and assignments and used different grading criteria, comparisons between teachers would not provide meaningful information.

Table 6
ANCOVA for Students' Final Achievement for Teacher A

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>136.87</td>
<td>1</td>
<td>136.87</td>
<td>3.56</td>
<td>.08</td>
</tr>
<tr>
<td>Approach</td>
<td>49.23</td>
<td>2</td>
<td>24.62</td>
<td>0.64</td>
<td>.54</td>
</tr>
<tr>
<td>Residual</td>
<td>769.76</td>
<td>20</td>
<td>38.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>955.86</td>
<td>23</td>
<td></td>
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</tr>
</tbody>
</table>

Table 7 presents unadjusted and adjusted group means of final achievement among the three instructional approaches for teacher A.
Table 7

Unadjusted and Adjusted Group Means of Final Achievement Among Three Approaches for Teacher A

<table>
<thead>
<tr>
<th>Approach</th>
<th>Unadjusted Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>82.03</td>
<td>79.96</td>
</tr>
<tr>
<td>Non-role</td>
<td>81.39</td>
<td>83.79</td>
</tr>
<tr>
<td>Role</td>
<td>83.92</td>
<td>83.25</td>
</tr>
</tbody>
</table>

Table 8 provides within class comparisons of students' final achievement for teacher B. The effect of the covariate was significant, $F(1, 18) = 11.17, p < .05$. But, there was no significant effect for the instructional approach on students' achievement, $F(2, 18) = 1.72, p > .05$.

Table 8

ANCOVA for Students' Final Achievement for Teacher B

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>1054.19</td>
<td>1</td>
<td>1054.19</td>
<td>11.17</td>
<td>.00*</td>
</tr>
<tr>
<td>Approach</td>
<td>324.17</td>
<td>2</td>
<td>162.09</td>
<td>1.72</td>
<td>.21</td>
</tr>
<tr>
<td>Residual</td>
<td>1698.83</td>
<td>18</td>
<td>94.38</td>
<td></td>
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</tr>
</tbody>
</table>

Total | 3077.19 | 21 |

*p < .05
Table 9 presents unadjusted and adjusted group means of students' final achievement among the three instructional approaches for teacher B.

**Table 9**

**Unadjusted and Adjusted Group Means of Final Achievement Among Three Approaches for Teacher B**

<table>
<thead>
<tr>
<th>Approach</th>
<th>Unadjusted Mean</th>
<th>Adjusted Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>61.98</td>
<td>60.98</td>
</tr>
<tr>
<td>Non-role</td>
<td>61.93</td>
<td>73.67</td>
</tr>
<tr>
<td>Role</td>
<td>72.00</td>
<td>62.75</td>
</tr>
</tbody>
</table>

**Students' Collaborative Behaviors**

Each of the ten collaborative behaviors was analyzed using a two-way MANOVA. If the F-ratio was significant, a univariate analysis was conducted. Further, if the result of the univariate analysis revealed a significant difference, then a multiple range analysis was provided.

Table 10 presents the group means (\( \bar{x} \)), standard deviation (SD), standard error (SE) for each collaborative behavior for the classes taught by each teacher and among the different instructional approaches. Group means are expressed as the number of times a particular behavior was exhibited by group members per observation period.
Table 10
Descriptive Statistics for Each of Ten Collaborative Behaviors

<table>
<thead>
<tr>
<th></th>
<th>Teacher A</th>
<th>Teacher B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trad</td>
<td>Non-role</td>
</tr>
<tr>
<td>k</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x̄</td>
<td>3.71</td>
<td>1.91</td>
</tr>
<tr>
<td>M</td>
<td>1.30</td>
<td>1.13</td>
</tr>
<tr>
<td>SD</td>
<td>0.49</td>
<td>0.40</td>
</tr>
<tr>
<td>x̄</td>
<td>20.75</td>
<td>20.88</td>
</tr>
<tr>
<td>MP</td>
<td>5.13</td>
<td>7.16</td>
</tr>
<tr>
<td>SD</td>
<td>1.94</td>
<td>2.53</td>
</tr>
<tr>
<td>x̄</td>
<td>4.78</td>
<td>6.06</td>
</tr>
<tr>
<td>OB</td>
<td>1.93</td>
<td>4.98</td>
</tr>
<tr>
<td>SD</td>
<td>0.73</td>
<td>1.76</td>
</tr>
<tr>
<td>x̄</td>
<td>13.61</td>
<td>16.06</td>
</tr>
<tr>
<td>D</td>
<td>6.14</td>
<td>6.84</td>
</tr>
<tr>
<td>SD</td>
<td>2.32</td>
<td>2.42</td>
</tr>
<tr>
<td>x̄</td>
<td>1.06</td>
<td>1.03</td>
</tr>
<tr>
<td>E</td>
<td>0.61</td>
<td>0.79</td>
</tr>
<tr>
<td>SD</td>
<td>0.23</td>
<td>0.28</td>
</tr>
<tr>
<td>x̄</td>
<td>1.83</td>
<td>1.25</td>
</tr>
<tr>
<td>R</td>
<td>1.38</td>
<td>0.62</td>
</tr>
<tr>
<td>SD</td>
<td>0.52</td>
<td>0.22</td>
</tr>
</tbody>
</table>
(Table 10 continued)

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Teacher A</th>
<th>Teacher B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trad</td>
<td>Non-role</td>
</tr>
<tr>
<td><strong>k</strong></td>
<td>19.24</td>
<td>9.88</td>
</tr>
<tr>
<td><strong>W SD</strong></td>
<td>4.68</td>
<td>2.77</td>
</tr>
<tr>
<td><strong>SE</strong></td>
<td>1.77</td>
<td>0.98</td>
</tr>
<tr>
<td><strong>k</strong></td>
<td>3.49</td>
<td>2.78</td>
</tr>
<tr>
<td><strong>RT SD</strong></td>
<td>2.62</td>
<td>1.87</td>
</tr>
<tr>
<td><strong>SE</strong></td>
<td>0.99</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>k</strong></td>
<td>0.43</td>
<td>0.31</td>
</tr>
<tr>
<td><strong>WA SD</strong></td>
<td>0.40</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>SE</strong></td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>k</strong></td>
<td>2.36</td>
<td>8.34</td>
</tr>
<tr>
<td><strong>OFF SD</strong></td>
<td>0.45</td>
<td>4.13</td>
</tr>
<tr>
<td><strong>SE</strong></td>
<td>0.17</td>
<td>1.46</td>
</tr>
</tbody>
</table>

**Note.** D = discussing  E = encouraging  M = managing
MP = manipulating  OB = observing  OFF = off-task  R = reading
RT = reporting  W = writing  WA = waiting.

The results of testing the supplementary hypotheses for each of the ten collaborative behaviors are presented in Tables 11-16. Table 11 shows that there was no interaction effect on students' collaborative behaviors, $F(20, 62) = 1.55, p > .05.$
Table 11

MANOVA for Interaction Effect on Students' Collaborative Behaviors

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Value</th>
<th>F</th>
<th>DF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilks</td>
<td>0.44</td>
<td>1.55</td>
<td>20, 62</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Table 12 indicates the result of MANOVA for instructional approach on students' collaborative behaviors. Instructional approach did have a significant effect on students' collaborative behaviors, \( F(20, 62) = 4.08, p < .05 \).

Table 12

MANOVA for Instructional Approach Effect on Students' Collaborative Behaviors

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Value</th>
<th>F</th>
<th>DF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilks</td>
<td>0.19</td>
<td>4.08</td>
<td>20, 62</td>
<td>0.00*</td>
</tr>
</tbody>
</table>

\*\( p < .05 \)

Table 13 presents the results of MANOVA for each of the ten collaborative behaviors among the three instructional approaches. Only one significant effect was found for writing behavior for instructional approach, \( F(2, 40) = 17.82, p < .05 \).
Table 13

Univariate Analysis of Each of the Ten Collaborative Behaviors for
Instructional Approach

<table>
<thead>
<tr>
<th>Behaviors</th>
<th>Hypoth. MS</th>
<th>Error MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managing</td>
<td>1.08</td>
<td>2.08</td>
<td>0.52</td>
<td>.60</td>
</tr>
<tr>
<td>Manipulating</td>
<td>74.12</td>
<td>25.88</td>
<td>2.86</td>
<td>.07</td>
</tr>
<tr>
<td>Observing</td>
<td>30.66</td>
<td>13.02</td>
<td>2.35</td>
<td>.11</td>
</tr>
<tr>
<td>Discussing</td>
<td>41.82</td>
<td>28.25</td>
<td>1.48</td>
<td>.24</td>
</tr>
<tr>
<td>Encouraging</td>
<td>0.05</td>
<td>0.28</td>
<td>0.18</td>
<td>.84</td>
</tr>
<tr>
<td>Reading</td>
<td>0.53</td>
<td>1.80</td>
<td>0.29</td>
<td>.75</td>
</tr>
<tr>
<td>Writing</td>
<td>321.33</td>
<td>18.03</td>
<td>17.82</td>
<td>.00*</td>
</tr>
<tr>
<td>Reporting</td>
<td>9.64</td>
<td>3.65</td>
<td>2.64</td>
<td>.08</td>
</tr>
<tr>
<td>Waiting</td>
<td>0.10</td>
<td>0.43</td>
<td>0.24</td>
<td>.79</td>
</tr>
<tr>
<td>Off-task</td>
<td>46.49</td>
<td>21.23</td>
<td>2.19</td>
<td>.13</td>
</tr>
</tbody>
</table>

Univariate F-tests with (2, 40) degrees of freedom

*P < .05

Table 14 presents the results of a multiple range analysis for writing behavior among the three approaches. The mean frequency of writing behavior in the "traditional" class (\(\bar{x} = 17.10\)) is significantly higher than both non-role assignment (\(\bar{x} = 8.41\)) and role assignment classes (\(\bar{x} = 9.84\)). No significant difference was found between the role assignment (\(\bar{x} = 9.84\)) and non-role assignment classes (\(\bar{x} = 8.41\)).
Table 14

Multiple Range Analysis for Writing Behavior by Instructional Approach

<table>
<thead>
<tr>
<th>Approach</th>
<th>Groups</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-role</td>
<td>14</td>
<td>8.41</td>
</tr>
<tr>
<td>Role</td>
<td>17</td>
<td>9.84</td>
</tr>
<tr>
<td>Traditional</td>
<td>15</td>
<td>17.10*</td>
</tr>
</tbody>
</table>

Note. The mean frequency of the traditional group is significantly higher (p < .05) than the role assignment and non-role assignment groups.

Table 15 presents the results of MANOVA for the teacher's effect on students' collaborative behaviors. There was a significant teacher effect on students' collaborative behaviors, $F(10, 31) = 8.46, p < .05$.

Table 15

MANOVA for Teacher Effect on Students' Collaborative Behaviors

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Value</th>
<th>F</th>
<th>DF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilks</td>
<td>.27</td>
<td>8.46</td>
<td>10, 31</td>
<td>.00*</td>
</tr>
</tbody>
</table>

* $p < .05$

Table 16 presents the results of a univariate analysis on each of the ten collaborative behaviors for teacher effect. The teacher had a significant effect on managing, $F(1, 40) = 4.35, p < .05$, manipulating, $F(1, 40) = 11.12, p < .05$, observing, $F(1, 40) = 15.04, p < .05$, reading, $F(1, 40) = 10.65, p < .05$, and writing $F(1, 40) = 8.24, p < .01$. No significant effect
was found for the other behaviors. The mean frequency of students' managing behavior in the classes of teacher B (\( \bar{x} = 3.58 \)) was significantly higher than the classes of teacher A (\( \bar{x} = 2.69 \)). As for manipulating behavior, the classes of teacher A (\( \bar{x} = 19.20 \)) showed a significantly higher mean frequency than the classes of teacher B (\( \bar{x} = 14.16 \)). The classes of teacher B (\( \bar{x} = 10.43 \)) showed a significantly higher mean frequency of observing behavior than the classes of teacher A (\( \bar{x} = 6.26 \)). The classes of teacher B (\( \bar{x} = 2.88 \)) showed a significantly higher mean frequency of reading behavior than the classes of teacher A (\( \bar{x} = 1.58 \)). The mean frequencies of students' writing behavior for teacher A (\( \bar{x} = 13.60 \)) were significantly higher than for teacher B (\( \bar{x} = 9.97 \)).
Table 16

Univariate Analysis of Each of the Ten Collaborative Behaviors for Teacher Effect

<table>
<thead>
<tr>
<th>Behaviors</th>
<th>Hypoth. MS</th>
<th>Error MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managing</td>
<td>9.03</td>
<td>2.08</td>
<td>4.35</td>
<td>.04*</td>
</tr>
<tr>
<td>Manipulating</td>
<td>287.70</td>
<td>25.88</td>
<td>11.12</td>
<td>.00*</td>
</tr>
<tr>
<td>Observing</td>
<td>195.80</td>
<td>13.02</td>
<td>15.04</td>
<td>.00*</td>
</tr>
<tr>
<td>Discussing</td>
<td>1.44</td>
<td>28.25</td>
<td>0.05</td>
<td>.82</td>
</tr>
<tr>
<td>Encouraging</td>
<td>0.22</td>
<td>0.28</td>
<td>0.79</td>
<td>.38</td>
</tr>
<tr>
<td>Reading</td>
<td>19.15</td>
<td>1.80</td>
<td>10.65</td>
<td>.00*</td>
</tr>
<tr>
<td>Writing</td>
<td>148.55</td>
<td>18.03</td>
<td>8.24</td>
<td>.01*</td>
</tr>
<tr>
<td>Reporting</td>
<td>0.10</td>
<td>3.65</td>
<td>0.03</td>
<td>.87</td>
</tr>
<tr>
<td>Waiting</td>
<td>0.10</td>
<td>0.43</td>
<td>0.22</td>
<td>.64</td>
</tr>
<tr>
<td>Off-task</td>
<td>40.05</td>
<td>21.23</td>
<td>1.89</td>
<td>.18</td>
</tr>
</tbody>
</table>

Univariate F-tests with (1, 40) degrees of freedom

*P < .05

The Relationships Between Collaborative Behaviors and Achievement

The relationships between collaborative behaviors and students' achievement were calculated by using Correlation Analysis. Since different teachers were involved in this study, the correlation analysis on behaviors and achievement was conducted separately for each teacher. Table 17 presents the correlation matrix for teacher A. It indicates that
there was a significant relationship between reading behavior and students' achievement, $r = .46, p < .05$. The other behaviors showed no significant relationships with students' achievement. But, several interesting relationships were discovered. The relationship between encouraging behavior and observing was significant, $r = .42, p < .05$. Several significant negative relationships were noted between: reporting and observing, $r = -.45, p < .05$; reporting and discussing, $r = -.48, p < .05$; reporting and reading, $r = -.45, p < .05$; manipulating and waiting, $r = -.48, p < .05$; and off-task and writing, $r = -.52, p < .05$. 
Table 17

Correlations Between Students' Achievement and Ten Collaborative Behaviors for Teacher A

|   | WA | .11^a |   | .62^b |   |   | RT | .18 | .24 |   |   | .40 | .26 |   | W | -.52* | .12 | .05 |   |   | .01 | .58 | .83 |   |   | R | -.27 | -.12 | -.45* | .09 |   |   |   | .20 | .59 | .03 | .67 |   |   |   |   | E | -.23 | -.26 | -.36 | .10 | .10 |   | .29 | .23 | .08 | .63 | .65 |   |   |   |   | D | -.17 | -.11 | -.48* | -.10 | .08 | .29 |   | .43 | .63 | .02 | .64 | .71 | .16 |   |   |   | OB | -.28 | -.27 | -.45* | -.15 | .10 | .42* | .21 |   | .19 | .21 | .03 | .48 | .65 | .04 | .33 |   |   | MP | -.25 | -.48* | -.03 | .06 | -.04 | .20 | -.23 | .23 |   | .25 | .02 | .89 | .80 | .85 | .36 | .28 | .28 |   |   | M | -.14 | .20 | .00 | .24 | .37 | -.06 | .04 | -.23 | -.06 |   | .53 | .34 | .99 | .27 | .07 | .78 | .84 | .28 | .78 |   |   | LAB | -.14 | -.29 | -.30 | -.02 | .46* | .01 | .12 | -.17 | .10 | .18 |   | .51 | .17 | .16 | .94 | .02 | .98 | .58 | .44 | .66 | .39 |   | OFF | WA | RT | W | R | E | D | OB | MP | M |
Note. D = discussing E = encouraging M = managing LAB = students' achievement MP = manipulating OB = observing OFF = off-task R = reading RT = reporting W = writing WA = waiting.

a = correlation coefficient
b = level of significance

*p < .05
Table 18 presents the correlation matrix for teacher B. It indicates that there were significant relationships between waiting and off-task behaviors, $r = -0.43$, $p < 0.05$; discussing and encouraging, $r = 0.58$, $p < 0.05$; manipulating and writing, $r = -0.43$, $p < 0.05$; and managing and reading, $r = -0.53$, $p < 0.05$. There were no significant relationships between any of the collaborative behaviors and students' achievement.
Table 18
Correlations Between Students' Achievement and Ten Collaborative Behaviors for Teacher B

<table>
<thead>
<tr>
<th></th>
<th>WA</th>
<th>RT</th>
<th>W</th>
<th>R</th>
<th>E</th>
<th>D</th>
<th>OB</th>
<th>MP</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>-.43*</td>
<td></td>
<td>.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-.03</td>
<td>.38</td>
<td>.90</td>
<td>.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.33</td>
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<td>.03</td>
<td>.13</td>
<td>.86</td>
<td>.91</td>
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<td></td>
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<td>-.16</td>
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<td>.07</td>
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<td>.98</td>
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<td>-.29</td>
<td>.16</td>
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<td>.02</td>
<td>.09</td>
<td>.26</td>
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<td>-.03</td>
<td>-.23</td>
<td>-.43*</td>
<td>.01</td>
<td>-.21</td>
<td>-.04</td>
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<td>.35</td>
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<tr>
<td></td>
<td>.07</td>
<td>.31</td>
<td>.04</td>
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<td>-.53*</td>
<td>-.01</td>
<td>.03</td>
<td>-.19</td>
<td>.21</td>
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<tr>
<td></td>
<td>-.08</td>
<td>.00</td>
<td>-.23</td>
<td>-.17</td>
<td>.03</td>
<td>.18</td>
<td>.00</td>
<td>.06</td>
<td>-.23</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>WA</td>
<td>RT</td>
<td>W</td>
<td>R</td>
<td>E</td>
<td>D</td>
<td>OB</td>
<td>MP</td>
</tr>
</tbody>
</table>
Note. D = discussing  E = encouraging  M = managing  LAB = students' achievement  MP = manipulating  OB = observing  OFF = off-task  
R = reading  RT = reporting  W = writing  WA = waiting.

a = correlation coefficient

b = level of significance

*p < .05
Chapter V

Discussion and Conclusions

Introduction

The purpose of this study was to investigate the effect of the levels of group cooperation on students' achievement during a series of physical science laboratory activities. Six intact seventh grade physical science classes taught by two teachers with each teacher instructing three classes were selected from two middle schools. Two teachers who are familiar with the cooperative learning strategy and experienced in the implementation of the desired instructional approaches for laboratory activities were chosen. The students were randomly assigned to groups of three and stratified on the basis of achievement and gender. For each teacher, one of the classes was taught with a traditional approach (no cooperative goal structure). The other two classes were assigned to a cooperative goal structure (role assignment and non-role assignment). For the role-assignment group, each student was assigned a specific role (i.e., manager, investigator, and recorder) but students in both traditional and non-role assignment groups were not assigned a role. Individual laboratory reports were solicited from students learning in the traditional learning condition while a group report was submitted by the students learning in the cooperative conditions. All the students remained in the same groups during the study, but the students in the cooperative
learning groups with role assignments switched roles for each laboratory activity.

Students' collaborative behaviors within the groups were observed during a period of six weeks. Students' achievement on lab related assessments were used to examine the difference among the three instructional approaches taught by the same teacher. Students' overall achievement before the study was used as a covariate in the analyses of differences of achievement among the three instructional approaches. Comparisons of students' collaborative behaviors were conducted using a two-way MANOVA to examine different behavior patterns among the instructional approaches as well as teachers. If the MANOVA $F$-ratios were significant, univariate analyses were conducted to examine the significant effects on each of the ten collaborative behaviors. Then, post-hoc comparisons were used to examine the differences within the univariate analyses.

Interpretation and discussion of results follow immediately. Several limitations of the study will also be discussed. Finally, recommendations for future research, as well as implications of this study will be presented in the final sections.

Interpretation and Discussion of the Results

The discussion of the results focuses on three areas. These are: (1) students' achievement, (2) students' collaborative behaviors, and (3) the relationships between collaborative behaviors and students' achievement.
Students' Achievement

No significant differences on the students' final achievement were found with respect to the three instructional approaches followed by each teacher. The present findings do not support the hypothesis that students assigned to cooperative learning groups would achieve better understanding of science concepts and practical skills as measured by their accumulated grades on lab reports and paper-and-pencil unit tests. In short, the present findings do not support the results reported by previous studies. Humphreys et al. (1982) stated that the cooperative learning experience promoted greater retention of material than did the competitive and individualistic approaches. Okebukola and Ogunniyi (1984) reported that cooperative learning approaches were superior on achievement as measured by a 50 item multiple-choice science achievement test. But, in the same study, Okebukola and Ogunniyi (1984) further pointed out that the competitive group outperformed cooperative and individualistic groups in practical skills, which included the ability to formulate problems, control variables, collect data, describe and interpret observed data, and draw conclusions. However, the present findings suggest that students in cooperative learning groups achieve at the same level as students in the "traditional" approach. Perhaps, the benefits of cooperative learning are specific to certain outcomes and, therefore, related to the assessment measure which is used.

In addition, two previous studies (Gail, 1990; Tingle & Good, 1989) were conducted to examine the effect of cooperative learning on students' cognitive growth and problem solving skills. Gail (1990) suggested that
cooperative learning groups were no more effective in training by cognitive conflict than were traditional groups. Tingle and Good (1989) reported that stoichiometric problem solving in cooperative groups is comparable to individual problem solving. Therefore, it appears that there exist mediating factors such as students' cognitive processes and the nature of the learning task, which affect the outcomes of cooperative learning groups. These factors need to be examined further if we are to assess the value of cooperative learning for students' achievement in the laboratory instruction.

On the other hand, the two teachers involved in this study said that they have been consistently using cooperative learning to encourage students to work together. Therefore, the students may have learned to cooperate at some level even when they were instructed in a traditional approach. Additionally, the level and extent of a teacher's implementation of the different instructional approaches might also influence students' engagement and achievement (James, 1984; Roadrangka & Yeany, 1985). Generally, a teacher might feel more comfortable with one of the three instructional approaches.

Finally, the effect of cooperative learning on students' achievement might not be accurately measured by lab reports and teacher made tests. The effect of applying a cooperative learning strategy to laboratory instruction might be more validly determined by an alternative assessment method such as one which focuses on science laboratory process skills (Kanis, Doran, & Jacobson, 1990), which involve not only students' abilities in manipulating, measuring, and recording, but also the higher level thinking skills of explaining, investigating, and
reasoning. Based on the aforementioned results and discussion, it appears that the effect of cooperative learning in the science laboratory may be less powerful than the results which have been obtained in other content areas involving problem solving skills and science content oriented achievement (Johnson, 1981; Johnson et al., 1986; Johnson et al., 1980; Okebukola, 1985; Okebukola, 1986a; Okebukola, 1986b; Okebukola & Ogunniyi, 1984; Sharan, 1980; Slavin, 1980; Tjosvold et al., 1977). Stallings and Snyder (1977) stated that similar teacher's implementation in different approaches could be used to explain students' similar achievement on inquiry skills. Further, the present findings indicated that students behaved the same in lab regardless of goal structure and this could explain the lack of effect of the cooperative goal structure on students' achievement. In fact, students' cooperation within lab groups is greatly influenced by the nature of science labs. Students normally cooperate in lab situations because they need to share equipment, materials, and think together to solve encountered problems. Therefore, if increasing the effectiveness of laboratory instruction is a concern, other teaching strategies such as guided discovery should be further investigated and applied.

**Students' Collaborative Behaviors**

A teacher effect was found for five of the ten collaborative behaviors, managing ($F = 4.35$), manipulating ($F = 11.12$), observing ($F = 15.04$), reading ($F = 10.65$), writing ($F = 8.24$) with degrees of freedom (1, 40) and level of significance at .05. No teacher effect was found for the other five
behaviors which included discussing, encouraging, reporting, waiting and off-task. The only behavior affected by instructional approach was writing behavior. In summary, it appears that teacher effect is more dominant than the instructional approach in the form of a particular goal structure. In general, students' behavior patterns were significantly influenced by the teacher as opposed to the various goal structures. So, although students' collaborative behaviors vary depending upon their teacher, a similar effect is not noted as the instructional approach (e.g., role assignment) is varied.

The students in classes of teacher B more frequently performed behaviors such as managing, observing, and reading. However, the students of teacher A more typically engaged in manipulating and writing behaviors. These results can be explained by the following observation. Teacher A typically put all the required equipment at students' tables each lab day. Given the way teacher A supplied equipment, his students had more time to "manipulate." However, teacher B had students collect all materials and equipment from a table at the front of the room. Therefore, the students of teacher B needed to move around and collect and gather materials and equipment more often than the students of teacher A. Further, teacher B provided handouts/worksheets for each laboratory activity. But, teacher A provided worksheets for only two of the seven laboratory activities. Five activities were written on the chalkboard or shown by transparencies. This difference in the presentation of the content of a laboratory would influence the mean frequencies of reading and writing behaviors. The students of teacher B also performed more observing behaviors. This
observing behavior included: watching other group members
manipulating, reading, and writing.

Even though teacher B liked to have students take data on the first
day of lab and answer questions on the next day, it was not uncommon for
students to spend most of their time collecting data and doing something
other than answering question on the second day. As a result, students
often did not turn in the lab reports until the following day. However,
teacher A allowed students to conduct their investigations and answer the
questions during laboratory periods. Students appeared to utilize their
time efficiently. They know how to use time to answer the questions when
they thought that a particular manipulation process was not critical to
them. Most students turned in their worksheets on the same day.
Therefore, the students of teacher A’s classes seemed to exhibit a higher
mean frequency of writing behavior as opposed to teacher B’s classes.

On the other hand, one of seven labs arranged by teacher A was
building hot rods. In this activity, all students were busy in constructing
their cars for the speed lab. A high frequency of manipulating behavior
was observed during this lab. This information also indicates that the
teaching style and specific lab activity are more important determinants
of behavior than goal structures.

The frequency of discussing behavior was high compared to the
group means of other behaviors in the classes of both teacher A (\( \bar{x} = 16.32 \))
and teacher B (\( \bar{x} = 15.96 \)). The frequency of encouraging was low for both
teacher A (\( \bar{x} = 0.97 \)) and teacher B’s (\( \bar{x} = 0.82 \)) classes. This result
supports the previous finding of Salend and Sonnenschein (1989). They
reported that the frequency of cooperative behaviors was typically lower
than frequencies of academic, or on-task behaviors. The frequency of waiting behavior in each teacher's classes was also very low. Further, there was no significant difference in the reporting behavior between the classes of teacher A ($\bar{x} = 2.65$) and teacher B ($\bar{x} = 2.75$). The frequency of off-task for the classes of teacher B ($\bar{x} = 7.37$) was a little higher although not significantly higher, for teacher A ($\bar{x} = 5.48$).

It should be noted that reporting behavior should have involved students' responding to the teacher's questions or answering the teacher's questions during a post-lab discussion. But, most of the reporting behaviors observed in this study were students talking to students in other groups about procedures and results. If students consistently talk to students of other groups, the frequency of student interaction within the group will be lowered. The "free interaction" among groups is an indication of the presence of total class cooperation. Such an atmosphere is directly related to the teacher as opposed to the goal structure being used.

The lower frequencies of off-task, waiting, and reporting behaviors may also increase the levels of cooperation within the group. But, how different behaviors ultimately affect students' achievement still needs further investigation.

An effect related to instructional approach was found for writing behavior, $F(2, 40) = 17.82$, $p < .05$. Students in the traditional classes ($\bar{x} = 16.96$) showed more writing behavior than the students following the other approaches (non-role assignment groups: $\bar{x} = 8.41$, role assignment groups: $\bar{x} = 9.84$). This result was because the students in the traditional
approach needed to submit individual lab reports for each investigative activity as opposed to a single group report.

A convergent pattern of students' behavior existed relative to the three instructional approaches. There was no significant difference on any of the ten collaborative behaviors except for writing behavior. The present findings indicate that the effect of different goal structures on students' behaviors is weak. When students were working with equipment or apparatus, they tended to exhibit similar behaviors regardless of the goal structure. Hertz-Lazarowitz et al. (1984) discussed that cooperation was more often noted in labs than other modes of instruction. The nature of labs promotes and allows students to cooperate at higher levels than other instructional situations even if students are not placed in a cooperative goal structure. In other words, students normally cooperate and help each other in the laboratory environment. So, the treatment effect of role assignment does not show a significant effect on the levels of group cooperation or achievement. Actually, the objectives of using role assignment for groups of students in lab conditions is twofold. First, the levels of group cooperation would be increased if each of the group members is assigned a specific role. Second, if the levels of group cooperation can be increased, the performance of laboratory work might be improved. However, there were no significantly different student-student interaction patterns among the three instructional approaches. The levels of group cooperation within each class were similar. Although role assignment may be useful in involving students equally in laboratory activities, this effect is not reflected in overall levels of group cooperation. In short, if students are
already working cooperatively, the specific distribution of responsibilities would not be expected to promote any differential group effects.

Investigating students' perceptions of laboratory (Lehman, 1989) may help to explain the conformity of these behavior patterns. Students' behaviors were possibly related to their perceptions of the value of science laboratory activity and the expectations for their behavior during laboratory activities.

Even though the analysis of students' collaborative behaviors exhibited a convergent behavior pattern among the three instructional approaches, there were several notable trends. In the classes using the role assignment approach, once student asked a group member to accept her ideas. She said "Every time, you don't listen to me. If you keep doing this, our grades will be lowered." Another student helped his group member make a graph. The group lab report needed to be turned in by the end of that period. But, the recorder did not know how to do the graph. Fortunately, the student (investigator) was very patient in helping the other student (recorder) complete the report. The above information provided the evidence that cooperation did occur in the cooperative classes.

Classroom management was a primary concern for both teachers. In particular, there was only a five-minute break between two periods at one of the schools. Consequently, teacher B typically reminded students of time with five minutes remaining. Usually, students were still busy doing their laboratory activities at this time. It was not uncommon for students to spend five to ten minutes setting up equipment and starting to collect data. At times, students could not finish collecting data because
there was not much time. Whenever the students heard the teacher remind them of time, they instantly stopped their activities because they understood that the teacher did not like to see the clean up of materials compromised. As a consequence, students often needed to repeat the procedures again the next day. As a result, the students did not appear to spend much time thinking about procedures and results.

On the lab days, it was not uncommon for the teachers to ask students to quit before asking them how far they had progressed. Even though the teachers sometimes asked students: "How many of you have not finished part A or part B," the students of a particular group are more aware than the teacher about how much work is left to be completed. So, a more appropriate way for the teacher to assess group process would be to say: "If you are still working, you need to notice the time. Groups who have completed their work may clean up and then discuss your results with your group members." Such an approach would teach students how to best utilize their time in the laboratory environment. If teachers attempt to have students assume more responsibility for their learning and make appropriate decisions during the laboratory activity, the teacher should use a cooperative group structure to increase students' perceptions of their responsibilities during laboratory work (Cohen, 1990; Shymansky & Penick, 1981).
Relationship Between Collaborative Behaviors and Students' Achievement

It is interesting to examine the relationship between the students' collaborative behaviors and their achievement. In teacher A's classes, only reading behavior was significantly correlated with students' achievement ($r = .46, p < .05$). However, the coefficient of determination, $r^2$, is only .21, predicting only 21% of the variance in students' achievement. Thus, the groups of students who know how to solve problems by reading the teacher's notes for their investigative activity tend to achieve better than the groups that just proceed by asking the teacher or talking to other students for help.

Further, there were several interesting relationships found among the ten collaborative behaviors. Off-task was negatively associated with writing behavior. Students who were concentrating on writing tended to show a low percentage of off-task behavior. Waiting behavior was also negatively correlated with manipulating behavior. Students who were busy in the manipulation of materials tended to spend less time waiting for the teacher's answers or attention. Reporting behavior was negatively associated with reading, discussing, and observing. Those students who talk to students in other groups, or the teacher, exhibit lower frequencies of reading, discussing and observing behaviors. Encouraging behavior was positively associated with the observing behavior. The students who typically observed the investigative activity of others also tended to show encouragement to their group members.
However, a different pattern of results was found in the classes of teacher B. First, none of the collaborative behaviors was found to have a significant correlation with students' achievement. Second, off-task behavior was negatively correlated with waiting behavior. The students who were off-task tended not to wait for or became impatient waiting for the teacher to help. But, the reasons for off-task behavior needs further investigation. In addition, writing behavior was negatively associated with manipulating behavior, suggests that within the same amount of time, the groups of students who tended to spend longer times on manipulation, tended to spend less time on writing. Reading was negatively correlated with managing behavior. Students showing more managing behavior tended to exhibit less reading behavior. Encouraging was positively associated with discussing behavior which may make that students show their encouragement through discussing. All the above relationships were not obtained in the classes of teacher A. A comparison of the different students' exhibited behaviors in both teachers' classes shows that the teacher has the most prominent effect on students' behavior. However, these differences in behavioral pattern are trivial with respect to achievement.

It was surprising to discover that reading behavior can be a more accurate indicator of students' achievement than manipulating, discussing, and writing, which have typically been considered as helpful for students' learning during laboratory instruction (Bates, 1982; Blosser, 1983; Hofstein & Lunetta, 1982; Raghubir, 1979; Walberg, 1991). Further, the present study does not support previous findings (Lyons, 1982; Yager, 1985) that discussing behaviors have an effect on students' achievement in
cooperative learning situations. Since very little discussion related to the understanding of the content of the laboratory activity occurred among all three approaches, it is not surprising that discussing was not a useful predictor of students' achievement.

The message here is that the cooperative learning goal structure (role and non-role) did not significantly influence students' achievement or their collaborative behaviors. It should be pointed out that the effect of the cooperative learning strategy may be compromised by the nature of task. In lab situations, initially students carry out procedures in a somewhat disorganized manner. Through discussing, thinking and practicing they find methods to solve the encountered problems. However, the observed frequencies of these behaviors are not highly dependent on the instructional approach, but heavily related to the nature of the learning task. Consequently, given the cooperative nature of lab work in science, the effect of altering goal structures has little influence. It is true that the laboratory can provide students "hands-on" opportunities, but it may not be accompanied with a "minds-on" aspect. Students need to be taught how to read, think, reconstruct and organize their concepts to make investigative activities more meaningful. Further, several processes such as: learning to read and reread the directions and manuals, thinking, constructing and reorganizing their concepts which are believed to be of critical value in laboratory activities (Decarlo & Rubba, 1991; Lehman, 1990; Marek, Eubanks, & Gallaher, 1990; Mcdermott, 1984) should not be assured to be logical consequences of implementing a cooperative goal structure. In short, the effect of cooperative learning on science laboratory activities may not be the panacea that it is provided to
be in other subjects areas such as language arts, reading, math, science (other than lab), and social studies (Johnson et al., 1981).

Limitations of the Study

Arranging to have the same teacher use all three instructional approaches was believed to be a better design than asking three teachers to each instruct one approach. But, it is possible that each teacher's implementation of a particular lesson will be affected by the other goal structures used in other classes on the same day. It is not easy for a teacher to consistently alternate approaches to instruction within the same day. And it is critical for each instructional approach to be implemented as accurately as possible. For example, the teacher is not supposed to respond to individual questions in cooperatively structure classes. The students are also encouraged to talk to their group members before talking to the teacher. But, both teachers and students may have difficulty obeying this "rule." Further, misunderstanding of the function of a specifically assigned role may have interfered with students' collaborative behaviors to some extent. It was observed that several students tended to think that the job of manager was easier than the other roles. Consequently, managers may have limited their levels of involvement with the group's investigative activity. In fact, besides gathering the necessary materials, the manager still can provide as much help as other group members.

On the other hand, students tended feel pressure to complete the investigative activity. Students might have thought that spending too
much time on discussing and receiving or giving help would be a waste time. Therefore, the levels of group cooperation could not be maximized beyond a certain level. Further, the cooperation which existed within the "traditional" groups also confounded the effect of applying the cooperative learning goal structures. However, it is probably inappropriate to assure that "traditional" lab group exhibit little cooperation. Consequently, the strength of a cooperative goal structure treatment is necessarily compromised.

Assessing students' performance in laboratory teaching is a perennial issue in science education. Lab reports and tests may ignore students' conceptual changes or the process of generating a concept. In fact, "real science happens in the head," not in observable lab behaviors (Pickering, 1987, p. 522).

Structuring heterogeneous groups (ability and gender) in each approach is an ideal design for this study. But, some deviations in ability among different groups still exist. Further, several groups were of homogeneous gender. Such grouping may have an extraneous effect on the results of this study.

A teacher's content knowledge and pedagogical skills are influential classroom variables. The degree to which variations on these factors influenced the results of this investigation are unknown.

Finally, the generalizability of this study is limited by the appropriateness of the teachers' implementation of both the cooperative learning strategy and laboratory instruction, the nature of the task, characteristics of the accessible population, grade level, and the methods of assessing students' achievement.
Recommendations for Future Research

This study should be replicated at different grade levels, and in different science classes to assess the effect of levels of group cooperation on students' outcomes in a laboratory setting. Further, matching classrooms of equal ability levels to different instructional approaches might be useful in preventing the confounding effect of initial differences among classes.

The nature of the teacher's effect on students' collaborative behaviors needs to be investigated further for the improvement of laboratory teaching as well as the implementation of cooperative learning. More information concerning the nature of the task (discovery oriented or verification type) and classroom atmosphere factors such as friendly, pleasant, supportive or rigid, cold, or dictatorial classroom instructional styles (Lederman & Druger, 1985) need to be further addressed to explain the teacher effect.

Simultaneously observing a group of three students is a fundamental element of measuring the levels of group cooperation. But, the differences among the individual groups within a class were not investigated and analyzed in this study. Such differences can "balance" when only means of all groups combined are used in statistical analysis. The levels of cooperation within the group can be measured in depth by selecting fewer groups of subjects. Several characteristics of successful groups such as cooperative, supportive, organization of problems into steps (Tingle & Good, 1989), ability to solve own problems, concentration
on task, work efficiency, use of reflective thinking, etc. can be investigated via qualitative case studies. Alternatively, understanding the characteristics of unsuccessful groups will also be helpful for teachers to improve the levels of group cooperation. The results of these kinds of studies will help teachers implement laboratory instruction more effectively.

Laboratory outcomes need to be assessed by methods other than paper-and-pencil tests and content-oriented achievement. If time permits, it would be worthwhile to assess students' science laboratory process skills (Kanis et al., 1990) by providing them the opportunity to conduct an investigative activity. The investigative process, student-student interaction, data analysis (Marek et al., 1990), answers of well-designed questions (Pickering, 1987) and the reporting of results will present more accurate information on students' learning.

Students' perceptions of laboratory as well as the teacher's perceptions need to be the focus of further research. Generally, the laboratory activity is arranged by teachers to enhance students' understanding of science concepts. But, students may perceive laboratory as either fun or boring, or a process of setting up equipment and measuring. In most students' minds, data collection is the lab, particularly for verification type laboratory activities. When students finish data collection, they believe they are done. But, students needs to be taught how to analyze and interpret data and how to use the results of data collection. Therefore, different perceptions on the roles of laboratory between teacher and students needs to be examined to improve the effect of laboratory teaching.
The relationships of collaborative behaviors and students' achievement needs to be studied. Discussing behavior was originally anticipated to influence students' cognition by the researcher of this study. But, little discussion related to the understanding of the content of laboratory activity actually occurred. Instead, students spent a lot of time on procedural questions such as: "What should we do first" or "Is this due today?" The relationship between the content of verbal interaction, as well as collaborative behaviors, and students' achievement should also be further examined. Further, mediating variables which may influence the effect of cooperative learning on the learning of practical skills, problem solving, concept learning, and reconstruction of science concepts need to be identified.

Implications for Science Teaching and Science Education Research

Although there is considerable evidence indicating that a cooperative goal structure has the most powerful impact in promoting achievement among the three kinds of goal structures, the results of this investigation indicate that, in science laboratory activities, the goal structure has little effect on students' achievement. In addition, convergent student-student interaction patterns were found. Students in the three instructional approaches exhibited similar behaviors regardless of the goal structures implemented by the teacher. It appears that the laboratory experience in science is cooperative by nature because students must share equipment, materials, etc. (Hertz-Lazarowitz et al., 1984). However, a teacher effect was found for five of the ten collaborative
behaviors. It appears that the teacher is more influential than the various goal structures employed.

Additionally, even though students spent most of their time on manipulating materials, discussing, and writing the relationship between these behaviors and achievement was very weak. On the contrary, reading seems to be the primary predictor of student achievement in laboratory activities.

Several previous studies do support the present findings. Using a qualitative study, Hertz-Lazarowitz et al. (1984) described students' interactive and noninteractive behavior in relation to the structural dimensions of the classroom. In their study, cooperation was generally higher in labs among five different modes of instruction. In other words, when students were assigned to the groups to conduct an investigative activity, they exhibited more cooperation than in the other learning conditions. So, the differences in the levels of group cooperation among the three instructional approaches were not significant since groups of students in science labs already exhibit high level of cooperation. Varying the goal structure ultimately has little effect.

The findings of Decarlo and Rubba (1991) address the relationship between teacher behavior and student behavior as exhibited during laboratory activities. It appeared that the lack of assistance from the teacher actually forced students to think and conduct the investigative activity on their own. Garity and Butts (1984) found that teacher management behavior was related to both students' engagement and student achievement. Kozma (1982) argued that students who tended to be more conforming were more satisfied with the structured approach,
while the more motivated students appeared satisfied with a less structured approach.

Further, there are four aspects which are highly related to the teacher's effect on students' behaviors: (1) the ways of presenting the laboratory activity such as: providing lab manuals or showing purposes, procedures, questions on the chalkboard, (2) the text: organization of the purpose, procedures, and questions in the lab manual (Pickering, 1987), (3) the type of laboratory: discovery versus verification (Shymansky & Matthews, 1974; Stallings & Snyder, 1977), and (4) teacher intervention (Oakley & Crocker, 1980) such as: monitoring group progress (Johnson & Johnson, 1987), quickly stopping inappropriate behaviors (Sanford, 1984), and giving necessary instructions. Consequently, it is clear that the laboratory activity is complex with a wide variety of variables which impinge on student learning. It is much too simplistic to assume that altering the goal structure will significantly alter students' achievement.

Reading behavior has been investigated in several studies (Cohen, 1991, Decarlo & Rubba, 1991; Hall et al., 1986; Kyle et al., 1979; Petersen, 1985; Pickering, 1987). However, no evidence was found for the relationship between reading and students' achievement. Meanwhile, the confounding effect of voluminous reading is created if the lab manual is not clearly organized, or students can not recast written materials into a manipulative procedure (Pickering, 1987). In essence, a thorough understanding of written lab instructions is the first step in conducting a lab activity. Therefore, it is interesting to note how reading behavior can affect students' cognitive processes and further affect their achievement in laboratory activities.
The most significant influence on students' behavior was the teacher, not the goal structure used. The benefits of "hands-on" activities are not automatically realized. Students need to understand the objectives of each specific lab. This step will help students to understand why and how to solve the problems presented. Otherwise, students may not learn anything after a period of much investigation. Further, the handout accompanying a laboratory activity is often designed by the teacher. Unfortunately, many students often feel that the directions printed on the handout are difficult to understand and follow. In fact, the teacher's reasoning process is often very different from that of the students. An investigative procedure for any science laboratory at the secondary level is easier for the teacher while it is very difficult for the students, whose formal reasoning is less well developed. Further, the concepts which teachers think are important may be perceived as unimportant because of the lack of students' ability to recognize, or be confused by, peripheral information (Johnstone, 1984). Therefore, teachers can not think that the laboratory itself can teach students concepts of science. Laboratory activities need to be appropriately organized, designed and presented. This is especially important with respect to the objectives and procedures for a particular activity. In short, sufficient guidelines for conducting an investigative activity should be provided.

Further, the post-lab questions provided by the teacher, or the lab handout, should be highly related to the laboratory activity. It is not a good idea just to put several questions which can be answered easily without actually doing the lab activity or cannot be answered even if students have been working diligently on the lab.
The principle of cooperative learning is simple. But, the implementation of cooperative learning is not easy (Johnson et al., 1988). Besides understanding the elements of cooperative learning, teachers need to use several kinds of "recipes" for group reports and role assignment. Hypothetical principles such as "stay with your group," "take turns," or "use quiet voices" do not work effectively in actual classroom practice. Most students need a guide to maintain group operation and work within their group.

Although several advantages of using a cooperative goal structure have been found in various subject areas and classroom contexts, it is not necessary to use cooperative learning all the time. The decision to use cooperative learning should depend on the objectives of teaching and the nature of the learning activities (Johnson & Johnson, 1987). For instance, if social skills development (i.e., getting students to work together) is a primary concern, it would be appropriate to use a cooperative goal structure.

On the other hand, the effect of cooperative learning will be enhanced in a supportive learning environment. It is ineffective to ask students to work cooperatively without providing a pleasant, friendly classroom climate. A teacher perceived by students as an enthusiastic, warm, and supportive instructor will be sure to implement cooperative learning more successfully (Good & Brophy, 1987).

Middle school students are often assigned to a group of two or three during a laboratory instruction. Therefore, teachers have a responsibility to teach them how to learn science through laboratory activities as well as how to work with other people. Before teaching their students, teachers
need to possess these knowledge and skills. In order to promote increased quality of teaching, courses which can provide both pre-service and in-service teachers with knowledge of how to implement laboratory instruction and cooperative learning strategies are needed.

The primary finding of this investigation remains that students typically cooperate during lab activities and so the outcomes produced by cooperative learning in other contexts are not as evident in science labs. Improvement of science lab instruction should pursue another focus which attends to specific teaching behaviors and organizational patterns.
References


Johnson, D. W., Skon, L., & Johnson, R. (1980). Effects of cooperative, competitive, and individualistic conditions on children's problem-


Kyle, W. C., Jr. (1977). An analysis of instructor and student behaviors in introductory and advanced laboratories of five science disciplines at the university level. (Master's thesis, the University of Iowa). Master's Abstracts, 17 (3). (University Microfilms, No. A 1304814)


Tjosvold, D., Marino, P. M., & Johnson, D. W. (1977). The effects of cooperation and competition on student reactions to inquiry and


