2003

The Impact Of Classroom Organization In Grade 4 On Student Achievement In Science

Edward Duncanson
Seton Hall University

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THE IMPACT OF CLASSROOM ORGANIZATION IN GRADE 4
ON STUDENT ACHIEVEMENT IN SCIENCE

By

Edward Duncanson

Dissertation Committee

Charles Achilles, Ed. D., Mentor
John Collins, Ed. D.
Patrick Michel, Ed. D.
Janice Volpe, Ed. D.

Submitted In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Education
Seton Hall University

2003
ABSTRACT

THE IMPACT OF CLASSROOM ORGANIZATION IN GRADE 4 ON STUDENT ACHIEVEMENT IN SCIENCE

Edward Duncanson
2003

While qualitative studies of teacher perceptions of classroom organization have been performed, quantitative studies linked to standards-based assessments are noticeably absent. Two questions guided the research: What is the impact of classroom layout in grade 4 on student achievement in science? How does space use change in a classroom when the furniture is reorganized?

The study was conducted in five classrooms in two rural, elementary schools. In two classrooms, teachers placed a large science materials table in the center of the room to make science activities a focal point for students. Two classrooms, that were used as controls, continued to operate using their established organization. The organization of the fifth classroom had included a large table in the center of the room for a number of years. This room was also used as a control.

Data were collected in three ways. Quantitative data were collected from the New York State Grade-4 Science Program Evaluation Test. Qualitative data were collected using the Classroom Spatial Utilization and Migration Form and by creating a classroom map. The data were presented in quantitative, narrative, and graphic forms.

Data from the New York State Grade-4 Science Program Evaluation Test were analyzed using a matrix published by the New York State Education
Department and by using SPSS software. Classroom spatial utilization and migration patterns were visually evaluated.

The guiding hypothesis that placing a large table in the center of the room would result in improved student performance was not totally supported by the data. Student density was correlated to student achievement. Specifically, classroom space per student was positively correlated to the inquiry science skills of classifying, manipulating materials, measuring, recording data, using non-standard measurement, and making predictions. Classroom arrangement was not as important as open space per student.

This research is important because classrooms that were designed for teacher-centered instruction may not be adequate for hands-on, inquiry science learning. A study of the way in which students engage in science activities relative to classroom organization could influence the instructional pedagogy of teachers. Recommendations regarding educational policy and classroom practice are presented.
Dedication

Fay

Ruth

Brian, Jennifer, Cynthia, Stephanie, and Michael

You are the wind beneath my wings.
ACKNOWLEDGEMENTS

“I want to know what I can do in the air and what I can’t, that’s all. I just want to know.”

Jonathan Livingston Seagull
Richard Bach, p. 14

I wish to thank the many individuals who unselfishly supported the discovery of what I can do. Their assistance was inspirational during my quest so I could ‘just know.’

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This project has been enriched by interaction with the thoughtful teachers who opened their classrooms to observation and analysis. The sharing of their thoughts through their wit and wisdom has contributed to a valuable experience for all of us. Their input helped to shape my thinking as I approached and analyzed this investigation.

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CHAPTER I

Introduction

"Hey dad! Look at the waterfall."

"Where do you see the waterfall, Michael"?

"Out there dad," pointing to the ocean horizon.

"I don’t understand. How do you know there is a waterfall out there?"

"Well, you can only see the water go out just so far and then it disappears. It must go over a waterfall."

"Great," I said to myself. "His brain is in gear. Here is this four-year-old recalling his experiences hiking mountain trails to waterfalls and playing in the cooling waters. Now he is recalling his knowledge and trying to construct an explanation of how the world is put together. His inquiring mind is applying prior knowledge to a different situation and explaining his new hands-on observations to the best of his ability. Piaget would be proud. This is a great place to understand how Michael thinks. But how will his teachers build and assess his processing skills in a classroom?" (personal communication, August 20, 1993)
Background

Classrooms that were designed for teacher-centered instruction may not be adequate for inquiry learning. The freedom provided by a beach environment is not duplicated in today’s classrooms. In order to promote inquiry learning, today’s classrooms must be redesigned to enhance student engagement with experiential activities.

Science teaching must involve students in inquiry-oriented investigations in which they interact with their teachers and peers. Students establish connections between their current knowledge of science and the scientific knowledge found in many sources; they apply science content to new questions; they engage in problem solving, planning, decision making, and group discussions; and they experience assessments that are consistent with an active approach to learning (National Research Council [NRC], 1996, p. 20).

Inherent in the inquiry process is the need for students to possess practical science skills that will enable them to carry out investigations effectively. Students need to use skills for observation, experimental design, and communication to meet the NRC standard quoted above. There is also a need to assess these skills in a way that makes sense.

Personal research (Duncanson, 2001) has established that students who are taught science using an inquiry-based, science-kit program score significantly higher on the New York State Grade-4 Science Program Evaluation Test (PET) than do students in classrooms where a hands-on approach to science is not used. On average, students in a hands-on, science classroom scored over four points higher on
the Performance (Form Z) portion of the Grade-4 Science PET as compared to students in a textbook-driven program. Also, there was no statistically significant difference in test scores between new students entering the school district in grade-4 and other students. In 2000 and 2001, on average, grade four students with disabilities scored near the average, and sometimes above the average, of the general population on the Performance (Form Z) portion of the Grade-4 Science PET.

Teachers often suggest that reading and writing ability are directly related to student performance on the Performance portion of the Grade-4 Science PET. Again, personal research (Duncanson, 2001) showed that the correlations of the reading or the writing score from the New York State grade-4 English Language Arts (ELA) exam and the Content, Skills, or Performance components of the Grade-4 Science PET were significant (for Reading to Content $r = .59$ and for Reading to Skills $r = .56$, $p < 0.01$; Reading to Performance $r = .36$ and Writing to Performance $r = .34$ both significant at $p < 0.05$ (Hinkle, Wiersma, & Jurs, 1998, p. 120). Reading skills are more closely related to the Performance score than are writing skills. In total, the correlations do not account for all the variance. One obvious conclusion is that other factors must be involved that hold the potential to improve student receptiveness to their hands-on experiences.

The inclusion of inquiry-based, hands-on science activities in a school program is costly and must be justified by improved student performance. The problem addressed in this investigation is to identify a way to increase student scores on the Performance Test portion of the New York State Grade-4 Science PET that is administered to all fourth-grade students. Research in England has led Harlan (2000)
to conclude that student's "knowledge of different materials may be extended by making and handling collections of plastics, rocks, various kinds of wood, metal, fabric and building materials" (p. 85). The author stated that classroom use of science kits could result in a high correlation of student's scores on the Skills portion of the written part of the Grade-4 Science PET to scores from the Performance portion. Using test data from the year 2000 and comparing the Skills score to the Performance test score, the correlation \( r = .43 \) was significant at the .01 level (Duncanson, 2001). This correlation does not account for all the variance in scores on the Skills portion of the test and the Performance portion. Other factors impact the linkage between student's hands-on experiences and achievement. One area of attention is classroom layout, including the use of space to influence learning.

The present research represents my starting point to sort out other factors that may help account for added variance in science learning as determined by New York State and measured on Form Z of the Grade-4 Science PET.

**Short History of Schools and Classrooms**

The organization of the modern classroom has evolved over time. School facilities have developed as a reflection of the educational philosophy of the time and as a way to supply students with shelter from the weather. In the early 1800's, the Lancastrian school system was transferred from England to the United States.

Lancastrian, or Monitorial system of teaching, which became all the rage in eastern American cities during the first three decades of the 19th century, may be thought of as an early application of the factory method to an educational
process. Brought to America by Joseph Lancaster, an English clergyman, the system utilized student monitors, who worked under the direction of one instructor to teach large groups of students—all learning the same items at the same time (Law, 1982, p. 7).

The Lancastrian school building consisted of a large room to contain 500 students of all grades, who sat on benches. This format provided for large-group instruction and established the principle of education for all children (Lowe, 1990).

The primary object of this approach was to reduce per-pupil cost to a bare minimum. Despite the bad pedagogy, harsh discipline and stereo-typed results, the Lancastrian approach to teaching made an important contribution to the common school movement by demonstrating that the education of masses of children was economically feasible (Law, 1982, p. 7).

The Lancastrian format began to disappear in the 1830’s as the American common school began to evolve. In this design, the teacher’s desk sat on a raised platform in the center of the room. Students would stand on the platform to recite lessons for the teacher. Between 1850 and 1900, while rural areas continued to have one-room schools, the graded school evolved in cities. This school usually contained 12 classrooms, an assembly hall, and a principal’s office. Each classroom held 55 students and provided desks that were bolted to the floor. This classroom organization placed the educational focus on teacher delivery. Following the Civil War Era, school construction changed from wood to brick.

The 1900’s witnessed the progressivism of Dewey, his ideas against regimentation of students and the focus on direct instruction. Class size decreased
from 50 to 30 to reflect new knowledge about individual learning and child growth and development. Teaching methodology changed to focus on observation and investigation. This approach required more space in the instructional environment. During this time, the high school also evolved. In the period after World War I, the high school curriculum was expanded to include physical education, health, and vocational education. All of these required more space. From the 1950's to the present, schools have changed in appearance as new materials have been developed but basic concepts of school design have remained unchanged. For a short period, the open classroom concept was tried but it was quickly defeated when teachers divided large open areas into small areas through the use of bookcases, coat racks, storage cabinets, and shelves (Lowe, 1990).

While the nature of science instruction has changed, basic changes in classrooms to meet new demands have not kept pace. Sargent (1991) reported that teachers generally have no training in classroom arrangement. This situation exists in spite of the fact that the "size and organization of instructional space had a major impact upon the learning environment of the school" (Lowe, 1990, p. v). Many classrooms, however, still look like the common-school model, with the teacher's desk in the front of the room and the student desks arranged in rows. A basic task of teachers in all classrooms is to organize the use of space in a way that promotes student achievement. Several studies have used interviews, surveys, and observations to gain information regarding teacher perception of classroom layout. Indeed, most research in this field has focused on classroom layout as a means to control student behavior. However, quantitative research on student achievement is limited and no
research has been located that connects classroom layout to achievement of inquiry standards established by the NRC.

**Purpose of Study and Questions**

The researcher explored the influence of classroom organization in grade 4 on student achievement in science. Two questions guided the inquiry:

1. What is the impact of classroom layout on student achievement as measured by the New York State Grade-4 Science PET?
2. How does spatial utilization change in a classroom when the furniture is reorganized?

**Delimitations of Study**

Four major decisions determined how this study would be carried out.

Two rural, elementary schools in one school district were selected as the sites of this study. The two schools were selected because they served a similar geographic area and ethnic population.

Only teachers who volunteered their classrooms were included in this study. The study was delimited to five classrooms with three of the classrooms in one elementary school and two classrooms in the second elementary school.

The New York State Science PET was used as a source of quantitative data. This test was administered during May 2002, to all students in the participating
classrooms. The test has been administered annually to students in all schools in New York State since 1989: the current version was introduced in 2000.

The treatment consisted of rearranging the classroom furniture to place worktables in the center of the room with student desks placed around the outside of the room. Teachers not using the treatment continued to use a traditional room arrangement that placed the student’s desks in the center of the room with workstations placed around the side of the room. In each school, one grade-4 class received the treatment and one grade-4 class did not. In addition, a fifth classroom was included as a control because the teacher had arranged her furniture with a large table in the center of the room for a number of years.

Teacher Processes

All teachers, both those who used the treatment and those who did not, received the same amount of training to use the four inquiry-based, hands-on science kits available for their grade level. The science kits dealt with the areas of physical science, earth and space science, life science, and ecology and were purchased from the Full Option Science System, Insights, and the Science, Technology and Children programs. The teachers created the ecology kit at each grade level. Teachers who have piloted the kits and developed curriculum materials to supplement the manufacturer-provided materials, presented a three-hour workshop to all the teachers on that grade level. During the workshop, teachers became familiar with the materials by performing all the activities that were designed for the students. In
addition, the workshop addressed the areas of major themes contained in the content; materials management; teaching strategies; and means of assessment.

Teachers ordered the science kits from a district managed Science Materials Center. The kits were delivered to the school with all materials required for the student experiments and teacher demonstrations. Teachers kept each kit for a 9-week period of time. The kit was then returned to the Science Materials Center to be refilled and made ready for use by another teacher.

All teachers had a science mentor teacher available for them to consult to discuss implementation issues. The mentor served in an informal capacity to offer teaching tips, share content knowledge, and provide general support to other teachers. This person is commonly known as the "science wiz" for the grade level. All teachers involved in the study had equal access to a science mentor.

Definitions

Architectural Facility – a setting which includes basic conditions of light, sound, temperature, and which includes qualities like color and texture (Loughlin & Suina, 1982, p. 2).

Arranged Environment – that pattern of furniture in an architectural facility (Laughlin & Suina, 1982, p. 4).

Arrangement – the act of putting in proper order. (McKechnie, 1968, p. 103).

Classroom – a room, often surrounded by four walls and a door, commonly designed to hold 30 students and often attached to a hallway with similar rooms (Ross, 1982, p. 5).
Classroom Environment — a place arranged to house books, desks, and materials and designed in a manner that adds to a student’s educational experience (Laughlin & Suina, 1982, p. xv).

Density — quantity or number per unit, as of area; as, the density of population. (McKechnie, 1968, p. 486).

Furniture — designed objects used for seating, sleeping, eating, or storage (Feirer, 1983, p. 13).

Grade 4 Science Program Evaluation Test — a multiple choice objective test of 45 items to evaluate science content and skills; a manipulative skills test of five stations to evaluate manipulative and inquiry skills (New York State Education Department, 1988, p. 1).

Inquiry — The National Science Standards define inquiry as: the diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (NRC, 1996, p. 23).

Science Process Skills — skills used by scientists in their work while thinking and studying problems. A list of the skills can include, but is not limited to: observing, inferring, experimenting, collecting and recording data, interpreting, and communicating results (Friedl, 1997, p. 1).

Seating — the arrangement of seats or of persons seated. (McKechnie, 1968, p. 1638).
Weaknesses

The need to carry out this study in a reasonable amount of time and the use of volunteers who were not accustomed to a research environment have contributed to a research design with some shortcomings. The small number of participating classrooms is a factor limiting the ability to generate statistically significant analyses, such as correlations. The participants were volunteers. For a variety of reasons, only one-half of the available teachers volunteered for this study.

The results are not generalizable to other school districts or even to other classrooms in this school district. Because of the manner in which students were assigned to a homeroom, at the time of the study, the results do not necessarily reflect a picture of what was happening in other classrooms. The results are only applicable to the classrooms that were studied. Readers may use the study and results to generate their own conclusions.

Intact classroom groups were used in the study rather than a random selection of grade-4 students. It was not possible to gain access to each grade-4 classroom in the two elementary schools selected for the study. Because homerooms are often created by matching student’s learning styles to the teacher’s teaching style, a classroom of students often represents a more homogeneous group than the grade population at large. Results of the study can only apply to the participating groups.

The research problem is approached using only two techniques. By using a mixture of qualitative and quantitative techniques, researchers can collect and analyze data using different methods. Results and conclusions reached using different sets of
data can be used to verify the correctness of each data set. The conclusions reached in a study are stronger when several techniques of data collection and analysis are used.

**Significance of Study**

Classroom learning environment research conducted with surveys has not attempted to link student and teacher perceptions to student achievement on standards-based assessments. Indeed, quantitative research linking the classroom environment to student achievement has been limited to preschool and college settings.

In view of the fact that English Language Arts (ELA) Reading and Writing scores do not have high correlations with the Practical score of the Grade-4 Science PET, there must be other outside factors that impact student success. The creation of appropriate spaces for students to work in while participating in inquiry activities could have an impact on student achievement.

A study of the way in which students engage in science activities relative to classroom organization could influence the instructional pedagogy of teachers. Special attention needs to be placed on strategies that will help students who have a history of difficulties in a traditional, content-laden program. According to Harlen (2000), students who traditionally are poor classroom performers may benefit by spending a greater amount of time engaged in experiential activities. If rearranging classroom furniture will assist the poorest performing students, it can be assumed that the strategy will positively impact all students. This strategy could be shared with teachers in a short amount of time avoiding the need for extensive staff development.
Teachers who try to incorporate hands-on activities into their science programs are faced with time constraints. If that problem can be positively affected through the creation of a classroom environment that facilitates student movement, access to materials, and peer interaction, then teachers will have gained a powerful tool to enhance student performance.

Most rooms used by people are arranged in a different manner than classrooms. Hall (1959) noted that in most rooms the furniture is arranged around the walls leaving the center of the room open for people to interact with each other. That is, the center of the room is common ground available for everyone's use. Classrooms are rarely arranged in this fashion. It is common for student desks to be placed in the center of the room leaving little pockets of open space around the sides of the room. This major difference in room arrangement is the primary focus of this study.

Form should follow function. Teachers need to understand the effects of the teacher-arranged environment more completely in order to compliment the educational program. Strange & Henderson (1981) stated that, "Psychologist Robert Gagne emphasizes that 'the essential task of the teacher is to arrange conditions for the learner's environment so that processes of learning will be activated, supported, enhanced, and maintained'" (p. 46).

Carefully and knowingly arranged, the environment adds a significant dimension to a student's educational experience by engaging interest, offering information, stimulating the use of skills, communicating limits and expectations, facilitating learning activities, promoting self-direction, and
through these effects supporting and strengthening the desire to learn
(Loughlin & Suina, 1982, p. xvi).

The traditional classroom arrangement using rows of desks and chairs may not
effectively support the acquisition of science skills required for advanced work in
schools to meet the 1990’s national standards movement. Inquiry-based science
programs need an environment that promotes working in teams, group problem
solving, and appropriate facilities to conduct experiments. A new kind of classroom
arrangement may help students investigate waterfalls in the ocean.

Therefore, educators should revisit the issue of how to arrange classrooms to
promote the acquisition of science skills. Knowledge gained in this study may
indicate a new approach to classroom layout and space use that will help improve
student achievement.

Organization of the Study

Chapter I provided an introduction that draws attention to the need to study
the arrangement of classroom furniture in grade four. The background highlighted the
emergence of the need to implement a hands-on science program that utilizes inquiry
as a major component of teaching pedagogy. The researchers earlier correlation study
highlighted the fact that test scores in reading, writing, science knowledge and
science skills do not account for all the variance in scores. A historical perspective on
the development of schools and classrooms clearly points out that the organization of
student seats has not changed to meet new instructional needs. This study focuses on
a small sample to explore whether or not the arrangement of classroom furniture influences student performance in science.

Chapter II is constructed in three sections to build a thesis for this study. The first section presents a review of national and state science standards and how they promote inquiry through teaching, learning, and assessment. A second section deals with the nonverbal messages communicated by classrooms. Section three presents an extensive discussion of pertinent literature related to the classroom environment. The section concludes by drawing attention to prospect that the “usual” arrangement of classroom furniture may not support inquiry instruction.

Chapter III explains the methods used to carry out the present investigation. Quantitative data were collected from the New York State Grade-4 Science Program Evaluation Test. The development of the test is reviewed and the five manipulative challenges the test contains are described. Qualitative data were collected using the Classroom Spatial Utilization and Migration Form and by creating a classroom map. Limitations of the study are discussed and a plan for collecting and evaluating the data is presented.

Chapter IV contains a factual presentation of the data. The classrooms are described and a map of each classroom showing the furniture arrangement is presented. Student movement around the classroom during a science lesson is diagramed to show how empty space in the room is used for student travel. An original diagram showing the interactional relationship of time and space in a classroom as they apply to inquiry science activities is presented. For the first time,
quantitative evidence is used to support the effect of classroom space on student achievement.

Chapter V presents the most important conclusions derived from each of the research instruments. Together, they demonstrate the impact of classroom furniture on student achievement and the attainment of hands-on science process skills. Recommendations for future research are set forth along with suggestions for immediate use by teachers to improve student achievement by altering the classroom environment.
CHAPTER II

Literature Review

Introduction

Chapter II sets the stage for this study of classroom organization. In it the researcher discusses prior research and literature, drawing upon the earlier work, and explains what data need to be collected to extend the research knowledge about classroom organization. The standards for science education mandate the use of inquiry as a teaching tool. Use of new teaching processes seems to require a careful consideration of classroom arrangements to support new teacher behaviors in the classroom.

National standards for science education appeared during the early 1990’s. They established a new focus for science education that incorporated inquiry into classroom programs. Science instruction is now expected to provide students with the opportunity to create their own explanations of events they experience in the world and explore ways to explain those experiences. The teacher serves as a mentor or coach providing opportunities for students to evaluate what they have learned and
help them to assemble their knowledge into a coherent model of the world (NRC, 1996).

**Mandates for New Pedagogy**

An inquiry-based pedagogy and perhaps new classroom arrangements are necessary to complement the new focus on the acquisition of science skills rather than the rote learning of the past. Teaching materials must be evaluated based on agreed-upon definitions for what inquiry teaching really means. A shift to inquiry teaching also implies a shift to hands-on assessment. Traditional classrooms and classroom organizations may not support inquiry teaching.

The possible influence of classroom organization on the attainment of instructional goals must be considered. Classrooms are important educational partners that deliver powerful, but unspoken, messages to students. Components of the classroom environment that have been studied by researchers include color, size, nature of lighting, air quality, student density, space usage, and furniture arrangement. Research indicates that these variables affect our perception of the environment (Hall, 1959; Hall & Hall, 1975; Moore, 1979; Loughlin & Suina, 1982; Grangaard, 1995; Achilles, Finn, Prout, & Bobbett, 2001). Matching the furniture arrangement to the activity may be needed to meet the needs of different kinds of educational goals.
National Standards

Recommendations from the American Association for the Advancement of Science (AAAS, 1993), are built on the basic idea that teachers do not need to teach more content but they do need to build scientific literacy and teach it effectively. The AAAS recognized that textbooks have grown thicker and thicker overwhelming teachers with the amount of content they are expected to teach. Rote learning has been conducted at the expense of deeper personal engagement and thinking (AAAS, 1993).

After an extensive review of research findings regarding science instruction, the AAAS reached a conclusion regarding students and their ability to use inquiry as a means of experimentation.

Upper-elementary and middle-school students may not understand experimentation as a method of testing ideas, but rather as a method of trying things out or producing a desired outcome. With adequate instruction, it is possible to have middle-school students understand that experimentation is guided by particular ideas and questions and that experiments are tests of ideas. Whether it is possible for younger students to achieve this understanding needs further investigation (AAAS, 1993, p. 332).

The AAAS (1993) requires inquiry science instruction through standards as outlined in *Benchmarks for Science Literacy: Project 2061*. The focus is on the mental application of knowledge to figure out how the world works. The AAAS encourages teachers to recognize science as a way of knowing about the world. "For students in the early grades, this emphasis should overwhelming be on gaining
experience with natural and social phenomena and on enjoying science" (AAAS, 1993, p. 4). The need to engage students in actively doing science is strongly recommended. "By gaining lots of experience doing science, becoming more sophisticated in conducting investigations, and explaining their findings, students will accumulate a set of concrete experiences on which they can draw to reflect on the process" (AAAS, 1993, p. 4).

The benefits of involving students in doing science is supported by research. Using interviews, classroom observations, and surveys administered to both teachers and students, Weaver (1998) studied three schools in a suburban area of Colorado. She stated that:

Discussions with students at the fourth, eighth, and tenth grade levels led to the conclusion that there are at least two approaches that can be used to maintain their interest in subject matter. The first is the use of hands-on activities, which was brought up by an overwhelming number of students in independent interview groups. The student interviews indicate they are more interested in laboratory work than other classroom activities, and there is evidence to suggest that this may correlate with improved student performance (p. 469).

Because scientific disciplines use inquiry in different forms, inquiry should occupy a primary position in the education of all students. Indeed, scientific thinking is a skill to help people consider happenings in the world as a part of everyday life. Great reliance is placed on the use of instruments to extend the human senses while gathering data and making observations of natural phenomena. Teaching should focus on the skills that enhance inquiry. The AAAS recommends that students learn
by practicing what they are doing. Student-designed questions should be used to engage students to actively collect and use evidence to create a model of the natural world. Interaction with peers is to be encouraged. A quality inquiry science program is one component that may encourage students to take advanced science classes. This approach addresses the needs of all students regardless of sex, religion, race, language or economic status. It is expected that long-term reform will be needed to develop quality materials and effectively make scientific literacy a reality for all Americans (AAAS, 1990).

The National Research Council, or NRC (1996) supported the AAAS (1993) standards in its publication on the National Science Education Standards. This document places a strong emphasis on the use of inquiry to enable students to engage in the same thinking and working processes that are used by scientists. Teachers are encouraged to provide students with opportunities to explore new materials, develop their own questions, perform investigations, and evaluate their findings. Thus, inquiry is promoted through the integration of hands-on science activities into the classroom program. Science is viewed as a way of knowing about the world. “Learning science is something students do, not something that is done to them” (NRC, 1996, p. 20).

The national standards for science as established by the NRC are clear. Inquiry science is mandated as a teaching pedagogy for all levels of schooling. While inquiry incorporates elements of discovery and constructivism, it is different in that inquiry involves students in creating questions that are new to them and then seeking answers. This process requires new classroom behaviors on the part of the teacher.
and the students. For one thing, not all students will be doing the same thing at the same time. All the participants must be able to function in this new dynamic.

Inquiry has become a fashionable term and has been applied to a variety of activities. Publishers and science materials providers routinely label their material as being inquiry-oriented even if it contains only directed activities. It is no wonder that there is confusion regarding the term. "Inquiry" is used in the National Standards once on page 20, and twice on page 23, to mean three different things. On page 20, inquiry refers to student-generated investigations. On page 23, inquiry refers to the various methods scientists use to study world and as the processes students use to gain understanding (NRC, 1996). In its purest form, inquiry refers to questions generated by students as a result of their own natural curiosity about the world around them and their self-designed experiments to investigate those questions.

**New York State Standards**

Doing science is also required by the New York State Elementary Science Core Curriculum Standards. Standard #1 states, "Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions" (New York State Education Department, 2000, p. 1). Performance indicators for this standard include:

- use appropriate scientific tools....observe and discuss objects and events and record observations....clearly express a tentative explanation or description which can be tested....use appropriate 'inquiry and process skills' to collect data....explain their findings to others....and actively listen to their
suggestions for possible interpretations and ideas (New York State Education Department, 2000, pp. 5 - 8).

**Inquiry Materials**

To support the effort to introduce inquiry into the nations’ classrooms, the Council of State Science Supervisors (CSSS) is currently in the process of developing a rubric to “assist a wide variety of audiences to develop an understanding of the desired characteristics of inquiry materials and to describe the extent to which a given material contains the descriptors outlined in the rubric” (CSSS, 2001, p. 1). The rubric is divided into four sections, with descriptors on four levels, which address: student understanding of science content; understanding how scientists study natural phenomena; the ability of students to design and conduct investigations; and the ability of students to develop the habits of mind needed to successfully conduct their own inquiry.

The rubric is designed to aid the teacher, materials reviewer, and materials developers select or design instructional materials that best suit their students’ needs. The ultimate goal of inquiry based science education will be to have students working with materials at (the highest level) on most descriptors but students usually can not start with materials at this level; they need to progress over time to that end (CSSS, 2001, p. 3).

Supported with funding from the National Science Foundation, three groups have developed multi-sensory laboratory-based science programs: Full Option Science System (FOSS), produced by the Lawrence Hall of Science; Insights,
produced by the Education Development Center; and Science, Technology and Children (STC), produced by the National Sciences Resource Center (Lowery, 1993). These materials were developed to engage students as scientists and reinforce what brain-based research tells us about teaching and learning. Jensen (1998) suggested that teachers directly engage students only in 15-minute bursts of time and use the remainder of learning time for student hands-on activities.

The science process (thinking) skills needed to accomplish discovery tasks that are required by the National Standards are embedded in the FOSS, Insights, and STC kits. Students who use the science kits are expected to become proficient in the skills through repetition in many different experiential settings.

Assessment of Science Process Skills

The science process (thinking) skills gained through inquiry are commonly measured on written exams. This is not the best way to test manipulative skills but the method commonly used. According to L. Rankin (personal communication, March 19, 2001), Director of the Institute for Inquiry at the Exploratorium, San Francisco, CA., “paper and pencil tests are given because people don’t trust teachers.”

Scientific thinking enables us to solve problems. Using this, students are able to build on what they know to construct bigger, more exact pictures of the world. To accomplish this task, students need to develop skills, such as laboratory skills, to enable students to use equipment properly; and mental skills to facilitate the formation of a hypothesis, designing an experiment or presenting data. These skills
are best assessed through exercises that look like the instructional activity they were patterned after. This requires a shift from a pencil and paper test and broadens the view of what effective assessment looks like. Through hands-on assessment we can validate a student’s ability to use science skills (Loucks-Horsley, et al., 1990).

Good elementary science provides an environment where students can extend their natural curiosity about the world around them.

As the nature of science education changes, so must our assessments. In general, assessment becomes a more integral part of the learning process, growing both deeper and broader to probe student understanding. Assessment becomes broader in the sense that it encompasses more varied formats of assessment. It is deeper in terms of measuring more complex skills. As students carry out laboratory investigations that challenge them to increase their conceptual understanding, the distinction between assessment and instruction blurs into a seamless whole, and there is near perfect alignment with standards (outcomes and expectations), programs (instruction), and assessments (Doran, Chan, & Tamin, 1998, p. 8).

“Assessment and learning are viewed as two sides of the same coin. One goal in these classrooms is to develop within the students the ability to monitor their own progress and that of the class as a whole (Layman, 1960, p. 22).

Herman, Aschbacher and Winters (1992) stated, “The fundamental role of assessment is to provide authentic and meaningful feedback for improving student learning, instructional practice, and educational options” (p. vi). This position was supported by Rezba, Sprague, Fiel and Funk (1995) who stated, “Assessment is the
process of gathering evidence of students' abilities and achievements" (p. x). They also stated, "Evidence about student performance in science is needed for a variety of purposes, such as making instructional decisions, tracking student progress, communicating judgments, and evaluating programs" (Rezba et al., 1995, p. x). Assessments should include performance tasks that provide students with different learning styles with a variety of opportunities to demonstrate what they know and are able to do. According to Doran et al. (1998),

One essential component of any assessment program is the development of appropriate assessment instruments and tasks, using formats that enable students to demonstrate what they know and can do. These assessment instruments and tasks must collect data and information that are consistent, informative, reliable, and valid for all students (p. 16).

Harlen (1997) took the position that students at all levels can use process skills and have them assessed while performing investigations. She said, "Unlike concepts, (science process) skills and attitudes apply in science activities with different subject matter, although the emphasis among them varies from topic to topic and with the experience of the children" (p. 171). She continued, "...when process skills are being assessed the children must be engaged in the exploration, investigation or discussion of subject matter within their understanding" (p. 172).

These points of view have been incorporated in the NRC National Standards. Assessment Standard A states that, "Assessments must be consistent with the decisions they are designed to inform: assessments are deliberately designed; assessments have explicitly stated purposes; the relationship between the decision and
the data is clear, and assessment procedures are internally consistent” (NRC, 1996, p. 78). The National Standards also state:

when students are engaged in assessment tasks that are similar in form to tasks in which they will engage in their lives outside the classroom or are similar to the activities of scientists, great confidence can be attached to the data collected. Such assessments are authentic (NRC, 1996, p. 83).

Research on students also supports the position that hands-on assessment is effective. Cohen (1995) noted that observations she collected suggested that hands-on performance-based assessment seemed to generate enthusiasm and excitement in students toward science. Weigold (1999) reported that students’ attitudes toward alternative assessment were much higher than their attitudes toward traditional forms of assessment for both males and females in grade 7. Cronin-Jones (2000) noted that students learned more about ecology in an out-of-doors setting than through traditional classroom learning.

Posing a question to students and giving them time to work together to create an answer, is an effective assessment technique (NRC, 1997). “Demonstrations of the process skills enable students to ‘do science.’ They permit hands-on or performance-based science” (Burz & Marshall, 1997, p. 12).

Nonverbal Communication

The effect of nonverbal messages delivered by the environment has been an area of growing concern (e.g. work by Hall [The Silent Language, The Fourth Dimension in Architecture: The Impact of Building on Behavior, and Beyond
Culture]). Effective methods of teaching and assessment of inquiry skills may require a change in the traditional classroom setting. An inquiry classroom delivers different messages to students than does a traditional classroom. “A major stumbling block to more effective instruction… has been and continues to be teachers’ over-reliance upon highly verbal teaching methodologies and strategies and a lack of understanding of the affective potency of nonverbal communication” (Achilles & French, 1977, p. ix).

There are multiple hidden dimensions of the nonverbal side of life that are part of our culture. Among these are time and space. In addition to other elements, these dimensions are important in a classroom. As defined by Hall (1976), culture has three attributes: it is learned, it is shared, and it consists of interrelated elements. Thus there is a culture in the classroom that people may not fully understand. “It is also possible to grow up and mature in a culture with little or no knowledge of the basic laws that make it work and differentiate it from all other cultures” (Hall, 1976, p. 91). Hall (1976) went on to state:

...Americans are captives of their own time and space systems – beginning with time. American time is what I have termed ‘monochronic’; that is, Americans when they are serious, usually prefer to do one thing at a time, and this requires some kind of scheduling, either implicit or explicit” (p. 14).

People deal with time in different ways. Monochronic people tend to deal with one focus at a time. Polychronic people tend to be involved in multiple tasks at the same time.
Monochronic time (M-time) and polychronic time (P-time) represent two variant solutions to the use of both time and space as organizing frames for activities. Space is included because the two systems (time and space) are functionally interrelated. M-time emphasizes schedules, segmentation, and promptness. P-time systems are characterized by several things happening at once. They stress involvement of people and completion of transactions rather than adherence to preset schedules. P-time is treated as much less tangible than M-time (Hall, 1976, p. 14).

Observational systems have been developed to assess verbal and nonverbal classroom interactions between students and teachers. The Flanders System of Interactional Analysis designated teacher behaviors as either Direct or Indirect. Ten categories of behaviors were designated. Categories 1-4 represented Indirect behaviors of accepting feelings, praising or encouraging, accepting and using student ideas, and asking questions. Categories 5-7 represented Direct behaviors of lecturing, giving directions, and criticizing or justifying authority. Categories 8-9 represented student talk that was teacher initiated, and student talk that was student initiated. Category 10 represented silence, confusion or some other non-designated behavior (Achilles, & French, 1977).

Achilles and French (1977) also reported on a system developed by French and Galloway. This system tried to match the 10 verbal categories of Flanders with 10 nonverbal categories that dealt with Encouraging and Restricting behaviors. The result was an Indirect/Direct Encouraging/Restricting (IDER) assessment tool. Achilles and Crump (1977) reported on five studies that used the IDER assessment
tool. The five studies dealt with: intellectually gifted elementary students; upper, middle and lower socioeconomic status elementary and secondary students; adult basic education; and two studies of elementary and secondary adjudicated delinquents. To compute the I/D ratio, the observer divides the number of incidents of Indirect communication by the number of incidents of Direct communication. A low ratio indicated that teachers were controlling the interaction and giving information. Only in the class of gifted students did the teacher talk less than the students resulting in a ratio that was over 1.0.

Achilles and French (1977) reported on verbal and nonverbal interactions between teacher and students that had been studied by Parker. Parker simultaneously studied students’ verbal and nonverbal behavior with the teacher’s behavior, verbal or nonverbal, which interacted with or influenced the students’ behavior. Using a modified version of the Flanders Interaction Analysis System or FIAS, he observed 53,447 behaviors of 461 elementary students. He found that “more than 90 percent of all the student behaviors recorded were nonverbal” (p. 47).

Some youngsters in every classroom are likely to depend on nonverbal cues. Achilles & French (1977) stated that, “Children from verbally deprived environments rely more on nonverbal communication cues; they are not as prepared for symbolic and cognitive learning as youngsters from verbally enriched backgrounds” (p. 54).

The verbally enriched child is comfortable with verbal cues and has developed a learning style which emphasizes the cognitive. There is little conflict between cognitive and affective dimensions of learning until the pupil’s secondary communication sources (nonverbal cues) exhibit obvious
incongruency with the primary sources (verbal cues). Conversely, the verbally deprived child, is uncomfortable in situations stressing the nonverbal, and hence, the affective (p. 56).

Nonverbal communication is important. Achilles and French stated that, “Youngsters learn to like school, teachers, education and themselves based upon their interpretation of nonverbal cues (affective), especially the youngster from verbally deprived environments” (pp. 56-57). They continued, “Research indicated that nonverbal cues are extremely influential in the communication process” (p. 57). Nonverbal cues can come in many forms: “light and dark, movement, touch, color, facial expressions, and sounds are among the early stimuli from which the very young child forms behavioral responses to the external world” (Achilles & French, 1977, p. 52).

Nonverbal communication as in what space, time, color, etc. may communicate, has often been overlooked when researchers examine the impact of teachers and the classroom setting on students. “Whether teachers are talking or not, they are always communicating. Their movements, gestures, tones of voice, dress and other artifacts, and even their ages and physiques are continuously communicating something to students” (Smith, 1979, p. 633). Communication is defined as extending beyond the spoken word. “Communication is viewed as a more inclusive term which, for example, incorporates the perceptions derived from observing a physical space such as a cluttered classroom in which no one is present but the viewer” (Smith, 1979, p. 634). In reviewing research on nonverbal communication, Smith (1979) noted that:
...most of these publications have served a useful role in emphasizing the significant influence of nonverbal communication in our lives and cultures, and have made commendable efforts to try to relate findings from other settings and disciplines to education. However, one major reservation concerning the suggestions is that many of them remain to be tested empirically in the classroom. Also, much of the earliest work make no attempt to relate the teacher’s nonverbal behaviors to resulting student products, the ultimate measure by which teachers are judged to be effective or not (p. 640).

"More recently, investigators have made increasing efforts to conduct research on nonverbal concepts in the actual school or classroom setting" (Smith, 1979, p. 640).

After a review of the literature related to the physical environment of the school, Weinstein (1979) concluded that, “the physical setting has assumed new significance” (p. 578). She cited research that supports the notion that college students who received the best grades tended to sit in the front and center of the classroom. She further stated that, “design can substantially affect attitudes and non-achievement behaviors, even when no impact on performance has been observed” (Weinstein, 1979, p. 582). The physical setting must be designed for proper interaction between the teacher and the learner. The furniture is an environmental variable that can be manipulated (Weinstein, 1992).

Classroom Environment

The premise that designed environmental factors significantly affect learning is supported by research (Hall, 1959; Hall & Hall, 1975; Moore, 1979; Loughlin &
Suina, 1982; Grangaard, 1995; Achilles, Finn, Prout, & Bobbett, 2001). Hall (1959) reported that the design of a room delivers silent but very loud messages to its occupants. Different people see different things in a room. “This means there is a relationship between people and patterns” (Hall, 1959, p. 121). The size of the room and the placement of the furniture will impact people in the room.

Given a large enough room, Americans will distribute themselves around the walls, leaving the center open for group activities such as conferences. That is, the center belongs to the group and is often marked off by a table or some object placed both to use and save the space (Hall, 1959, p. 171).

The appearance of the room speaks to people and influences their interactions with each other.

Spatial changes give a tone to a communication, accent it, and at times even override the spoken word. The flow and shift of distance between people as they interact with each other is part and parcel of the communication process (Hall, 1959, p. 175).

Hall & Hall (1975) focused their attention on the study of man’s use of space and the impact of buildings on human behavior. They reported that buildings did indeed impact human behavior. “It is quite clear that everyone sees the building from his own personal point of view” (Hall & Hall, 1975, p. 53). Unfortunately, many schools look like prisons. “Far from being passive, environment actually enters into a transaction with humans” (Hall & Hall, 1975, p. 9). In schools, teachers become the architects of interior space that must be designed for people. The “setting itself is a greater determinant of behavior than personality” (Hall & Hall, 1975, p. 42).
Moore (1979) addressed environmental issues from a psychological perspective.

The basic assumption which underlies most of the recent theoretical and empirical work on environmental cognition is the constructivist assumption. This assumption suggests that the environment is conceived of in different ways by different people. There is no one “environment” — rather “environment” is a mental construct. The environment is imagined differently by different people as a result of different life experiences. Humans do not apprehend the nature of the environment directly but through a highly developed interpretative process. This interpretative process acts as a filter — a scheme in Piaget’s terms — and it is these schemata which are the subject of environmental cognition research and theory. (p. 34-35)

Based on their research conducted in elementary classrooms, Loughlin & Suina (1982) also noted that the setting influences behavior.

The learning environment influences behaviors in many different ways. Environmental messages urge movement, call attention to some learning materials but not others, encourage deep or superficial involvement, invite children to hurry or move calmly. Environmental arrangements can also promote independence and self-direction, encourage use of skills, and lengthen or shorten the attention span. With or without teacher awareness, the environment sends messages and learners respond. The influence of the environment is continuous and pervasive, regardless of the program style of behavior expectations of the teacher. (p. 17)
The spatial arrangement of a classroom affects student behavior. Several studies have examined environmental factors such as color, lighting, and décor (Grangaard, 1995; Read, Sugavora & Brandt, 1999). Grangaard (1995) conducted tests in which she changed the wall color of classrooms and the color of the overhead lights. Changing the wall color and the type of lighting used resulted in fewer incidents of 6-year old students being off task and in students having lower blood pressure. Her experiment was accomplished in three phases.

The first phase was the original environment which consisted of the standard visual noise on the walls, bulletin boards of red and orange and white semi-gloss walls with cool-white fluorescent fixtures. The second phase was the test in which the walls were painted a light blue, the visual noise was returned to the walls and the lights were changed to a full-spectrum Duro-test Vita-light (Grangaard, 1995, p. 2).

During Phase 3, the field was returned to the original environment. “Three hundred ninety off-task behaviors were counted during the first phase (original environment) which was compared to three hundred ten off-task behaviors counted during the second phase (field test), a decrease of 22%” (Grangaard, 1995, p. 4). “A nine percent decrease (9%) in the mean blood pressure readings was recorded when the field test was instituted during Phase 2 of the study with a slight increase recorded during Phase 3 in which the field was returned to the original environment” (Grangaard, 1995, p. 5).

Achilles et al., (2001) investigated air quality as an environmental factor.
contributing to student behavior. They observed that students in regular-size classes (20-28 students) often became irritable and tired during the afternoon. In classrooms with small classes (15-17 students), students were full of energy all day long and well behaved. A graduate engineer suggested that the CO₂ levels be checked.

The engineer explained that CO₂ is related to the number of persons in a space, is cumulative unless well ventilated, and caused both drowsiness and lethargy that could result in low attentiveness that would be detrimental to teaching and learning. Class size, the number of students in the defined space, seemed to be a variable, as was the time of day. This translated into cubic feet of space per student (Achilles et al., 2001, p. 5).

Regular-size classes produced a larger amount of CO₂ and often exceeded the Occupational Safety and Health Administration (OSHA) prescribed level for healthy air by 9:30 AM. Classrooms with small cubic feet volumes became unhealthy at a faster rate than did larger volume classrooms. Even small classes (15-17 students) often exceeded the recommended OSHA level by the end of the school day (Achilles et al., 2001).

The effectiveness of classroom environments has also been investigated using survey instruments. One methodology for assessing and studying classroom environment is to survey student or teacher perceptions (Fraser & Walberg, 1981). The My Class Inventory (MCI), Learning Environment Inventory (LEI) and the Classroom Environment Scale (CES) are commonly used for this purpose (Fraser, 1989). Fraser and Walberg (1981) stated that, “students seem quite able to perceive
and weigh classroom stimuli in order to render valid judgments about psychosocial characteristics of their classroom” (p. 68).

**Student Density**

The size of a classroom and the amount of furniture in the room directly affect a person’s perception of being crowded and yet few investigations deal with density of the occupants in a classroom. “Nowhere else are large groups of individuals packed so closely together for so many hours, yet expected to perform at peak efficiency on difficult learning tasks and to interact harmoniously” (Weinstein, 1979, p. 585). The impact of student density has not been investigated well. “The impact of crowding on achievement is not yet clear, but the data indicating decrements in complex task performance warrant serious consideration” (Weinstein, 1979, p. 588).

Sommer (1971) studied college student’s perception of density and user satisfaction in a campus classroom. Sommer polled 422 students from 32 separate classes that used the room. Class sizes ranged from 5 to 22 with a mean of 13. As expected, the percentage of complaints about the classroom increased with an increase in class size. “There were approximately twice as many complaints about ventilation, room size, and overall satisfaction in the large classes as in the small classes (Sommer, 1971, p. 414).

Achilles (1999) also recognized the need to consider the issue of space in a classroom setting. He stated:

One place to start observing classrooms is to consider space, space use, and the environment or context of the teaching-learning process. The use of space,
proxemics, is one element of nonverbal communication and is important in establishing effect and affect. (p. 36-37)

Tanner (2000a) investigated the problem of determining how many students should be in a given space. He recognized that “the curriculum (activities for learning) should be the dictator of space needs for a classroom” (Tanner, 2000a, p. 1). He applied social-distance research findings that each student needs 49 square feet of space. The recommended size of an elementary classroom in the United States is 900 square feet. A classroom of this size should house only 17 students.

If there are too many people in a given space, we usually react negatively. Children react both by withdrawing, physically and socially, and by acting aggressively. The more people, the more empty space is necessary for people to feel comfortable. The feeling of being crowded is the feeling of being observed, of being in the continual presence of others (Tanner, 2000c, p. 5). He also stated that an elementary classroom should have at least 72 square feet of windows for natural light (Tanner, 2000a).

Swift (2000) studied the effects of student population density on academic achievement in grade three in 29 elementary schools in Georgia. She found that, elementary schools having an architectural square footage of less than 100 square feet per student tend to have significantly lower science, social studies, and composite ITBS scores than schools having more than 100 architectural square feet per student. Schools ranging from 100.27 to 134.1 architectural square feet per student had significantly higher ITBS science, social studies, and composite scores at the third grade level (Swift, 2000, p. 2).
Classrooms are typically 750 – 900 square feet in size. In many classrooms, the addition of furniture in a traditional design limits the mobility of special-needs students. An open classroom provides for greater flexibility for dealing with class groupings of different sizes and better accommodates students with special needs (Rydeen, 1999). Research suggests that classroom movement is minimized by the arrangement of desks and tables, which serve to focus student attention on the teacher.

**The Arranged Environment**

Adults are able to survive in classrooms because they arrange the furniture and decorate the room to suit their own needs. "Architects are adults who plan and design the use of space. Adults use public space vertically and in quite stationary, predictable ways – they sit, walk, and work in the designated space" (Achilles, 1999, p. 38). However, the arranged environment that is suitable for adults may be entirely the wrong arrangement for kids.

Although adults use space in very correct adult ways, kids will use the same space in very kid-like ways. ‘Rug rats’ use space horizontally and vertically. They spread and sprawl, and the teachers of these young children need space for education: spaces for desks, learning centers, aquariums, computers, displays, toys, coats, mats. A space suitable for 25 adults who may sit in rows of desks in a classroom is much too small for 25 K-1 youngsters eager to learn (Achilles, 1999, p. 38).
One place to begin the transformation of education is with better use of existing classroom space to provide a nurturing, learning environment (Simplicio, 1999).

The most obvious form of structure is the classroom itself – how you arrange the furniture, select and organize materials, and what you have on the walls. The physical environment conveys strong messages to children from the first time they enter the room. It can reassure them that their classroom is a place where they will feel safe, comfortable, and where they will do interesting things (Bickart, Jablon, & Dodge, 1999, p. 99).

Classrooms are dominated by furniture and materials for students to use. Organization of those items needs to be considered carefully. "In your classroom you most likely have tables, chairs, books, board or wall space, and different amounts of supplies. Organize what you have in ways that will make each day go smoothly" (Bickart, et al., 1999, p. 102).

The classroom not only provides a setting for teaching and learning but also actively participates in teaching and learning. "The physical learning environment has two major elements, the architectural facility and the arranged environment" (Loughlin & Suina, 1982, p. 1).

Spatial organization influences much of the movement and physical behaviors of children in the environment. Teachers accomplish this task by defining spaces within the environment, planning traffic patterns, and arranging furniture. Room arrangement is more than a casual responsibility or a matter of aesthetics, because spatial organization influences so many behaviors. New
spaces are created each time a piece of furniture is put in place, although some of those spaces may not be noticed by the teacher who created them. The spaces and their relationships still influence behavior, whether planned or not (Loughlin & Suina, 1982, p. 8).

“When behavior encouraged by the environment is expected and desired, teachers are more likely to respond in positive ways that support activities and learning” (Loughlin & Suina, 1982, p. 50). “The amount of teacher time that is spent in dispensing materials, presiding over routines, and managing child behavior can be minimized when the environment is arranged for that purpose” (Loughlin & Suina, 1982, p. 7). Conscious decisions should be made by teachers regarding the arrangement of classroom furniture.

Gifford (1976) noted that people seem to develop “environmental numbness” to unsuitable furniture arrangements. College psychology students were confined for 90 minutes in cubicles with an uncomfortable seating arrangement to work on an assigned task. None of the students rearranged the furniture to create a more satisfying environment. He noted, “that students in a classroom will repeatedly accept an impediment rather than adjust it to levels of comfort” (Gifford, 1976, pp. 6-7). Students squeezed through small spaces to move around rather than move the furniture. “None of them made more than a short-range adjustment of tables and chairs to accommodate his or her own body at the moment, and even these subjects were rare” (Gifford, 1976, p. 7). It was clear to Gifford that students will adjust to the furniture rather than adjusting the furniture to fit the situation.
Tanner (2000c) studied how the physical objects in classrooms interact with people. He concluded that because of classroom organization, “children are over managed. They have fewer and fewer opportunities to simply mess about and follow their dreams. Consequently, each successive generation is losing opportunities for delight and wonder” (Tanner, 2000c, p. 3). The factory model of classroom organization is not helping children learn.

One assumption supported by a Carnegie study ....is that schools are mindless, joyless, rigid, and petty. They destroy the hearts and minds of children in them. Back to basics is regarded as back to the old methods and old materials – back to the factory emphasis on worker productivity (teachers’ accountability) and quality control (student testing) (Tanner, 2000c, p. 3).

The influence of classroom environment on curriculum in the classrooms in which a new curriculum was introduced has also been studied (Suarez, Pias, Membiela & Dapia, 1998). They studied the student and teacher perceptions of the classroom climate. While finding that the teacher played a major role in the student reaction to a new curriculum, they also noted that spatial organization was an important factor. The researchers noted that there was less student involvement on task orientation, and order and organization in some classrooms. The researchers noted that in the poorer classrooms the “desks were screwed to the floor and arranged in rows” (Suarez, et al., 1998, p. 668). They concluded, “the spatial organization of the classroom may influence the social climate, at least in a negative way, when trying to work with small groups in a classroom with desks screwed to the floor” (Suarez, et al., 1998, p. 669).
Classroom Arrangement

Colbert (1997) noted that classrooms must be organized for optimal operation. By organizing classroom furniture, pathways are created to focus attention on specific activities. In classrooms “with open pathways that clearly lead to activities that offer enough to do, children manage on their own” (Colbert, 1997, p. 23).

Open pathways that lead to specific places in classrooms are comparable to the design of parking lots. Parking areas should be efficient in the use of space while allowing for maximum efficiency for pedestrians. Respect for pedestrian flow habits is shown by placing isles perpendicular to the front of the room. Large dimensions make it easier and faster to reach an assigned space. Wider isles are also needed for two-way traffic (Packard, 1981). A typical parking area is designed to be twice as large as the size of the cars the area is expected to hold. Entrances and exits are purposely designed so they are a continuation of traffic isles. Expansive isles make a large visual impression (Federal Sign and Signal Corporation, 1974).

Poor classroom organization is commonly evidenced by a need for the teacher to provide a great deal of student direction. Wandering and unruly behavior are encouraged when the classroom contains dead spaces and pathways that lead to nowhere. Teachers find it difficult to assist individual students and attain their objectives in such a setting (Colbert, 1997).

When a classroom is arranged with assigned seats for each child, a teacher is apt to see the Real Classroom as the area where the desks or tables are grouped, while viewing the remaining spaces in the back or around the edges as leftover space (Loughlin & Suina, 1982, p. 26).
"If arrangements were more flexible, they could be changed for short-term use, shifting from small, much needed working spaces to a larger single area used now and then for everybody" (Loughlin & Suina, 1982, p. 33). "When permanent seating for every child is a priority in classroom arrangement, spatial organization often begins with the placement of desks or tables, and further organization revolves around the permanent seating" (Loughlin & Suina, 1982, p. 36). When the desks are in rows, ... "much total space is used to separate desks and make room for movement" (Loughlin & Suina, 1982, p. 37).

One "correct" room arrangement really doesn’t exist. "The typical classroom arrangement, with students’ desks lined up in neat rows, makes it easy for custodians to do their jobs but tough for teachers to freely walk among their student’s desks. Teachers should be able to get around the classroom quickly and frequently (Weaver, 2001, p. 2).

Elementary teachers typically divide the day into "activity segments" as a way to organize teaching time. "The physical elements of a segment consists of features of the milieu such as the size of the space, the arrangement of furniture, and the objects available for use in the segment" (Ross, 1982, p. 3). The pledge to the flag requires room to stand, reading circles need a new seat arrangement, and seatwork may need individual desks. Art projects may require students to sit together to share materials. If the classroom arrangement does not match the activity, the segment will operate at less than optimal level (Ross, 1982).

If the furniture can be moved, teachers must decide where to place each item. Many older schools are furnished with furniture that is difficult to move and does not
lend itself to be used in different design patterns. This handicap precludes teachers from providing students with interactive learning experiences. Modern pedagogy requires, “flexible floor plans, modular furniture and highly mobile learning tools” (Lyons, 2001, p. 2).

“One basic design issue that teachers must address when arranging the classroom is whether the space should be organized in terms of personal territory or by functions” (Ross, 1982, p. 10). Arrangement by personal territory places the focus on students. Arrangement by function places the emphasis on the skills and content being taught. Most classrooms use a mixture of both arrangements. Ross (1982) has found there are basic design criteria needed to facilitate activities in a classroom that is organized by function. The room needs to have: clear, visible pathways; 1/3 to ½ open space; an absence of dead space which leads to horsing around by students; and no areas that are hidden from view due to furniture placement. If these guidelines are not followed, teacher control becomes an issue. Small pieces of furniture in the room can easily be moved to help achieve the desired results. On average, teachers can rearrange classrooms in 1.4 minutes to achieve desired outcomes (Ross, 1982).

Sargent (1991) reported on the influence the arrangement of seats in a classroom has on the relationship of the student and the teacher.

By arranging student seating in certain configurations, the teacher communicated how she wished the students to move about the room. The location of her desk and storage units limited the students’ range of action within the classroom. The arrangement of the furnishings communicated to the students how the teacher regarded them and the teacher’s role. The spatial
arrangement was the physical expression of the relationship that the teacher expected to have with the students. If the teacher's desk was front and center and the student desks were in straight rows, the students knew what the relationship was and their actions in the relationship. Students who were seated at single desks expected they would work alone. Students seated at tables expected they would be working in collaboration with other students (p. 94).

Sommer (1969) reported on his research with 50 students regarding how they positioned themselves for different activities. When working cooperatively (building a single design together), they sat side-by-side. However when they were competing against each other for a single prize, they tended to sit corner-to-corner or face-to-face. When they worked on separate tasks, they arranged themselves in a catty-corner pattern (Sommer, 1969, p. 19).

Research conducted by the School Design and Planning Laboratory (SDPL) at the University of Georgia has resulted in specific design recommendations for organizing classrooms. They recommend the creation of spaces designed for small group work and "ample spaces that allow students to circulate" (Tanner, 2000b, p. 2).

Other researchers have made similar observations regarding seating arrangements. With desks pushed together, side-by-side, with a narrow central aisle, attention is focused forward and talking is not permitted. No one needs to look at anything but the front of the room and no one needs to talk to anyone but the teacher (Manke, 1994).
One of the resources that teachers have in maintaining the agenda of public cooperation is to build part of the structure before students arrive, preempting building space before conflict can arise. This can be done through the structuring of time and space in the classroom (Manke, 1994, p. 6).

Circular seating arrangements are good for discussions while desks placed in rows produce individual on-task behavior. Teachers also find that some students work best in a setting away from others (Wengel, 1992).

To create additional space, teachers commonly arrange desks in groups of 3, 4, 6 or 8. This conserves space and increases communication among students. Keeping the desks arranged in groups creates broad walkways in the room. The increased space also made it easier for students to find a place to take short breaks. Importantly, the extra space enabled students to work for longer periods of time. “More child-child interactions take place in small groups. When the kids return to whole group, there is a higher level of contributing ideas, and random conversations” (Shapiro & Aiello, 1974, p. 8). It is recommended that a circular seating arrangement be used during discussion (Wengel, 1992).

Kattef, & Manzelli (1974) raised questions about the placement of the teacher’s desk in the room and even questions whether the teacher even needs a desk in the room. She found that it was not uncommon for teachers to use their desks only when students were not in the room. In one classroom it was found that the teacher had established 1/3 of the available floor space for her private use. She also found that many teachers moved their desks away from a front-and-center position in the room. In a decentralized position, teachers could privately discuss work with students.
Howard (1975), Rice (1999), and Langer (2001) believe that while classroom space must be planned for, the interaction between the teacher and the students is more important. Langer (2001) stated that the success of teachers..."may not be so much based on arrangement as on interaction with students" (p 843). Rice (1999) emphasized that time teachers spend with small groups is important. Interaction between the teacher and students occurs with a greater frequency in classes where the teacher walks around. Teachers need to control three major elements of the classroom: time, space, and student-teacher interactions. Most teachers plan for time but ignore space and student-teacher interactions. If students are to be involved in constructive activities, the activity must be planned and a space for it to happen must be provided (Howard, 1975).

Aligning themselves with national science standards, the New York State Education Department, or NYSED, recognized that classroom space is a major factor that must be considered in the delivery of inquiry-based instructional and assessment programs. Describing a desirable classroom environment that delivers positive nonverbal messages to its occupants they state,

There is an adequate student/teacher ratio, sufficient space in the classroom, access to the out-of-doors, and sufficient materials to promote a favorable affective environment, enabling adequate teacher management of activities, especially those hands-on activities involving performance tasks and problem solving (NYSED, 2000, p. 34).
Center of the Room

The typical classroom organization is not supportive of all activities. “Straight rows of desks all facing the same direction, for example, impede the development of strong, activity-oriented science programs” (Strange & Henderson, 1981, p. 46). “Students need opportunities to interact, share ideas, and draw upon each other’s discoveries” (Strange & Henderson, 1981, p. 46). Using a table in the center of the room as a site of instruction and for the distribution of materials draws attention to the fact that this activity is important.

If desks are in the center of the room, the majority of children’s activities will be around their own desks. The center of the room is a focus area regardless of its use for desks, as open space, a large group area or a small group area. Students will spend less time at their own desks if the desks are placed on the outside of the room (Lowe, 1990).

Teachers do not work from formal knowledge when they arrange their rooms. They have learned from the experience of arranging their own classrooms in certain ways or have borrowed ideas from other teachers. Sargent (1991) reported, “Teachers in the present study were aware of the effects of the classroom arrangement on student performance and behavior largely through personal experience and professional trial and error” (p. 95). She goes on to report, “The task of room arrangement seemed to be accomplished through a process akin to action research. The teacher knew when the correct arrangement had been achieved; when student behavior was correct” (p. 97).
It can be seen from the data collected by Lowe (1990) that if student desks are in the center of the room, the majority of children’s activities will be around their own desks. The center of the room is a focus area regardless of its use for desks, as open space, a large group area or a small group area. Students will spend less time at their own desks if the desks are placed on the outside of the room.

**Diagramming Interacting Events**

Many researchers have addressed different aspects of individual components of classroom culture: nonverbal communication, time, space, density, furniture arrangement, and migration patterns. Hall (1976) pointed out that all these dimensions are important in a classroom and indeed, are linked to each other. He described events as occurring in chains. “An action chain is a set sequence of events in which two or more individuals participate” (p. 124). He also stated:

There are practical reasons for studying action chains, some of which are particularly relevant to the tasks of the architect or planner. Thus research in how space is used reveals that failure to get detailed data on the action chains and situational frames in which they occur can result in breaking the chain. This happens when architectural spaces don’t fit the activities they house. (p. 124)

Hall (1976) stated that new alternatives to regimented thinking plans must be opened. “Our way of thinking is quite arbitrary and causes us to look at ideas rather than events – a most serious shortcoming. Also, linearity can get in the way of mutual understanding and direct people needlessly along irrelevant tangents” (p. 18).
Rather than creating a stream of linear events, Senge (1990) viewed events as occurring in interrelated cycles. He stated that we must look for cycles in a system where events cause other things to occur cyclically. Understanding the whole picture is necessary in order to understand how to make meaningful changes. "The real leverage in management situations lies in understanding dynamic complexity, not detail complexity" (p. 72). However, this is not the focus that most people take. "Most systems analyses focus on detail complexity and not dynamic complexity" (Senge, 1990, p. 72).

Systems thinking requires people to use non-linear models because all systems can be represented as loops. In each loop, leverage lies in the balancing loop - not the reinforcing loop. The reinforcing loop contains the thing that is getting better and the action that leads to the improvement. The balancing loop contains a limiting factor, which serves to resist continual improvement. To change the behavior of the system, you must identify and change the limiting factor. Systems thinking "means organizing complexity into a coherent story that illuminates the causes of problems and how they can be remedied in enduring ways. The key is strengthening the ‘fundamental solution’ of building service capacity" (Senge, 1990, p. 128).

The meanings delivered by nonverbal messages are inextricably tied to the context of the event. Context is a matter of what you pay attention to or do not. Messages occupy a continuum from high to low.

A high-context (HC) communication of message is one in which most of the information is either in the physical context or internalized in the person, while very little is in the coded, explicit, transmitted part of the message. A
low-context (LC) communication is just the opposite; i.e., the mass of the information is vested in the explicit code. Twins who have grown up together can and do communicate more economically (HC) than two lawyers in a courtroom during a trial, a mathematician programming a computer, two politicians drafting legislation, two administrators writing a regulation, or a child trying to explain to his mother why he got into a fight (Hall, 1976, p. 79).

Summary

Chapter II has reviewed the literature and research related to the teaching of inquiry science in a classroom environment. National and state science standards were presented to establish the need to include inquiry teaching and learning in science programs. The assessment of science skills as a fundamental component for the improvement of instruction was discussed. An extensive review of nonverbal messages delivered by classrooms was put forth. The argument was made that the proper use of the center of the classroom promises to promote inquiry-based science programs. While research from the 1980’s and 1990’s broadened our knowledge of the classroom environment, the fact remains that there is scant quantitative research into the impact of classroom organization on student achievement.

Chapter III explains the methods used to carry out the present investigation. Five classrooms in two elementary schools, located in a rural area, volunteered to participate in the study of the influence of classroom arrangement on student achievement in science. Limitations of the study focus on the need to use intact
classrooms rather than a random sample. Quantitative data was obtained by using a state prepared test. Qualitative data, obtained by using the Classroom Spatial Utilization and Migration Form and a classroom map, were gathered to evaluate the classroom environment. This portion of the study focused on the architectural classroom, the furniture arrangement, and student movement patterns.
CHAPTER III

Research Design

Choice of Methods

In this study of the influence of classroom organization on student achievement in grade-4 science, the researcher used existing instruments to evaluate program effectiveness and student behavior. The New York State Performance Test (Form Z) component of the Grade-4 Science PET was used to generate quantitative data. The performance portion, Form Z, of the PET requires students to manipulate materials, record data, and write extended responses to a series of questions.

The Classroom Spatial Utilization and Migration Form developed by Lowe (1990) was used to assess student movement in the classrooms (Appendix A). These data were used to relate classroom arrangement to student use of classroom areas during hands-on science activities.
Sampling Techniques and Instruments

A letter of solicitation was sent to 10 grade-4 teachers in two elementary schools of the same school district. A background essay devoted to classroom furniture arrangement was developed by the researcher and attached to each solicitation letter (Appendix B). Five teachers agreed to participate in this study. One teacher in each school rearranged their classroom furniture to place work-activity tables in the center of the room for science instruction. Each classroom was somewhat different because of architectural differences and the available furniture. The researcher constructed a map for each room. For this research, classrooms were identified with a number. The school district and the elementary schools have been identified with a pseudonym.

The collection of quantitative data was a major component of this study. The focus of this study was to evaluate the link between classroom layout and student achievement. The Science PET was administered to all grade-4 students in late May. While the teachers are in different schools, the test was administered in each school in the same manner. The principals in each school considered the pros and cons of possible testing sites that included the classroom, library, cafeteria, and the gymnasium. On the negative side, the gymnasium presents students with an unfamiliar testing site and the acoustics are usually poor. However, the gymnasium offers a large space where materials can be set-up and left for the duration of the exam. Therefore, the principals in both selected schools decided to establish one test center in the school gymnasium. Classes were brought individually or in groups to the
gymnasium for the test. At least one teacher and one additional helper monitored each class. Following state guidelines, the test was administered uniformly at each site.

D. Reynolds (personal communication, February 23, 2002) reported that the performance test was designed in 1986-89 under his direction, while he was the Bureau Chief of Science Education for the NYSED. R. Doran, from the State University of New York at Buffalo, assisted in the test development. The initial performance test (Form X), first administered in May 1989, was followed four years later by Form Y. This in turn was replaced with Form Z in 2000. D. Reynolds (personal communication, March 19, 2002) has reported that the next form is planned for 2004 with the performance portion of the test changing from a program evaluation to a student evaluation.

D. Reynolds (personal communication, March 19, 2002) also reported that the New York State Department of Education would like to have the test changed every four to five years in response to teacher requests and to be able to deal with emerging issues.

Examples of teachers' comments that led to moving from X to Y were that they wanted new tasks, they wanted more time for the students at each station (from 7 [sic] min X to 9 [sic] min Y), and they wanted an integrated test booklet of both station directions and student questions. The test developers, with the advice of the Design Comm. [sic], reviews [sic] each of the requests and, if appropriate and feasible, designs [sic] the suggestions into pilot test materials and attempts to see if it will work in a large scale program (about 250,000 grade 4 [sic] students took the performance test in May 2001).
Examples of teachers' comments that led to moving from Y to Z were that they, the teachers not the students, were tired of the same test after 7[sic] yrs, but they still wanted a measuring station; they wanted more time for a student at each station (increasing it to 15 min.); they wanted a station where two students worked together; an [sic] they wanted the stations to be placed into a context. Again, the test developers attempted to come up with appropriate changes. (D. Reynolds, personal communication, March 19, 2002)

The 2002 Performance Test portion of the Grade-4 Science PET consisted of five stations with a different manipulative challenge at each station. Students either rotated through stations #1-#3 or #3-#5. At Station #3, two students work in a cooperative manner. Students work individually at each of the other four stations. Fifteen minutes are permitted for students to work at each station. While different scores are attainable at each station, each student could score a maximum of 29 points for the three stations.

At Station #1, students use their observational skills and knowledge of density to describe how objects behave in a liquid.

At Station #2, students classify common objects based on their physical characteristics.

Station #3 presents a Ball and Ramp Game in which students roll a rubber ball down a ramp into a plastic cup and measure how far the cup moves in relation to a finish line. When given a ping-pong ball, students must hypothesize how they can change the ball so it would push the plastic cup to the finish line (Appendix C).
At Station #4, students test four metal objects and four non-metal objects to determine if a magnet attracts them. They also use an electrical tester to determine if each of the objects conducts electricity.

At Station #5, students are presented with an unknown object, which they must first describe. The student then must write two questions about the object that could be directed to a scientist. Answers to the questions should help the student better understand what the object is.

The validity and reliability of the exam have been examined. J. Pinsonnault (personal communication, February 11, 2002), Associate in Educational Testing at the NYSED, stated that:

content validity is demonstrated by the classification of each item to a specific area of the syllabus (Appendix D). Reliability is addressed by deriving average item difficulties from aggregate data (Appendix E). The test is considered criterion-referenced and there is no specific passing score. Districts and schools use the test to compare the performance of their students as a whole over time.

Specific terms used as a part of the program evaluation are explained in documents provided by the NYSED (2000):

The term ‘item difficulty,’ as used for the Performance Test, refers to the degree to which the highest possible score for the item was obtained. It is the mean (or average) value of the scores for an item divided by the maximum score (expressed as a percent). For example, if an item difficulty is 50 for an
item with a maximum score of 4 credits, then the mean score on the item was 2.0 credits. (p. 24)

Classroom Visitation

Classroom visits to obtain information are a part of social science. According to Alford (1998), “The craft of social inquiry lies somewhere between art and science. It combines the creativity and the spontaneity or art (although art can be hard work) and the rigorous and systematic character of science (although science can be joyful)” (p. 8). The qualitative methodology used here is termed ‘grounded theory’ (Alford, 1998). Grounded theory is described by Babbie (1999) as being an inductive approach to understanding. That definition is appropriate here as the researcher used direct observations to identify patterns of human behavior.

After receiving permission from the school district superintendent to collect data from selected classrooms (Appendix F), classroom observations were made in each of the five participating classes. The Classroom Spatial Utilization and Migration Form (Lowe, 1990) was used in conjunction with the classroom map at two-minute intervals to diagram pathways used by students during a period of science instruction. The researcher used this instrument only to record patterns of movement. No data on individual students were collected at this time. The focus of the study was on the arrangement of the classroom furniture. Students and their teachers were participants in the study but they were not the subjects of the study. Between interval observations and data recording, the researcher made general observations regarding student-teacher interactions and classroom activities. The researcher practiced using
the instrument in non-participating classrooms to gain experience and increase the
trustworthiness of the data collection method. To gain naturalistic observations, visits
to classrooms were as unobtrusive and non-reactive as possible.

Limitations

The Mountain View Central School District (pseudonym) is a rural district
located 70 miles north-northwest of New York City. Typically, the residents work in
local businesses or commute by car, bus, or train to metropolitan New York City. The
district serves approximately 5,600 students.

The study focused on the students in heterogeneous classrooms in the school
district. In total, 19 fourth grade classrooms are housed in four rural, elementary
schools. The Indian Lake (pseudonym) and The Oak Ridge (pseudonym) Elementary
Schools were selected for the study. Each school serves an area of the school district
that is primarily rural in nature and features farms that raise corn, hay, cows and
racehorses. Farmland on the north side of the school district is also currently being
subdivided for residential housing. It has been reported for the northernmost town in
the school district that in the last 34 years, “the number of residences more than
doubled as the number of local dairy farms dropped to six from 72” (Hegedus, 2002,
p. 6). Students in the two schools are primarily Caucasian. The south side of the
school district contains a higher percentage of residential areas and fewer farms. Most
of the commuters to New York City live on this side of the school district. There is a
noticeable mix of people from different races, nationalities, and religious
backgrounds.
While the students in the two selected schools lived in similar geographic areas, their socio-economic status is different. The Indian Lake Elementary School had 711 students with 16% receiving a free or a reduced price lunch. The Oak Ridge Elementary School had 869 students with 28% of the students receiving a free or a reduced price lunch.

The composition of the sample classroom members was not treated in any way. Classes remained intact with all the students who were regular members of the class. Students classified by the Committee on Special Education (CSE students) and new entrants were not extracted from the sample.

Limiting the study was the fact that a new test was introduced for its first administration in May 2000. Therefore, comparisons can be made to only two prior years.

Class size cannot be planned for and therefore could be a major variable. However, it was expected that all grade-4 classes would be relatively the same size, containing 24-28 students.

Participating teachers volunteered to take part in the study. Therefore, "those who do not volunteer are not included. The ethical demand that participants be volunteers makes it difficult for researchers to obtain a random sample of any population" (Graziano & Raulin, 2000, p. 211). It could be inferred from their participation that these teachers possessed high levels of energy, were interested in the study, and are ready to try research-based approaches that will add excitement to their classrooms.
This study did not consider teacher background. Having a strong science background either from undergraduate work or participation in seminars, workshops or a natural interest in the subject certainly may have a positive influence on teacher performance in class and student performance.

Teaching experience was not controlled in this study. B. Adler (personal communication, March 22, 2001), Director of Staff Development for the Allegheny Schools Science Education and Technology (ASSET) Project in Pittsburgh PA., stated:

it is common to find that teachers use a new science kit in a mechanical manner the first time they incorporate the science material contained in the kit into their classroom program. During the second year, teachers begin to recognize that they need to increase their content background and they may undertake individual study to increase their knowledge. In year three, teachers begin to take a deeper look at assessments that are embedded in the science kits. With three years of experience behind them, teachers begin to extend activities found in the kit and begin to do things on their own.

This progression ignores previous experience and assumes that teachers expand their knowledge in a series of logical steps. The professional development of some teachers is likely to take longer than for other teachers.

Teaching style could not be controlled in such a limited sample. It is likely that a teacher who oversees a very controlled classroom will have difficulty managing an inquiry-based science program. On the opposite end of the spectrum is the teacher
who is comfortable with a classroom environment that is less controlled and permits students to self-direct part of their activities.

The presence of the researcher on site could cause students to act in a different manner. For this reason, multiple visits to each site were made so the researcher could gain experience with the instrument being used and a comfort level could be established with the students and teacher.

The teacher cannot change some elements of the classroom. The size and shape of the room, the number and placement of doors and windows, the nature of the floor surface, wall color, temperature, and lighting were beyond the control of the teacher. A diagram of each classroom was made and can be found in Appendix 1 of this study.

Three Data Collection Forms

Information from the classrooms was gained in three ways: numerical data was used from the NYS Grade-4 Science PET from each part of the five-station performance test; by using the Classroom Spatial Utilization and Migration Form; and from a classroom map.

Form #1

In May 2002, students took the NYS Grade-4 Science PET. This test has been administered annually to all grade-4 students in New York State to evaluate the effectiveness of science programs. Aggregate data are printed annually in the School
District Report Card and shared by elementary principals with their school staff: (Appendix G). There were no additional tests to be administered.

Student answers for the performance portion of the Grade-4 Science PET were written in a student answer booklet. The booklets for all classes were graded by a committee of trained teachers, selected by a school district administrator, from each of the district's four elementary schools. The majority of the teachers did not teach grade-4 students. All teachers graded test booklets of students who did not attend their school. Points awarded for individual questions in the student booklet were transferred to a machine-scoreable card. This data card was then processed at a nearby Regional Information Center and the results were reported to the school district for inclusion in the School District Report Card.

Form #2

The Classroom Spatial Utilization and Migration Form created by Lowe (1990) for use in Texas was modified to focus on schools in New York State and on those areas of the classroom that were important to this study. The utilization portion of the form was modified to more accurately reflect building materials used in New York. Additionally, Lowe included 'Small Group Areas' and 'Large Group Areas' on his form. These areas were commonly used during the normal school day while Lowe was making his classroom observations. 'Teacher Area' and 'Open Space Area' were substituted for the two 'group areas' on the revised form. The 'Open Space Area' includes any space on the floor which is not covered by furniture and is normally used as a pathway or space on the floor that students can use for large projects.
In addition, the Classroom Migration Form was further modified to provide space to permit recording comments made by teachers as supplemental information during informal, unstructured interviews. This format was used to enable teachers to verbalize their thinking rather than react to the bias of the researcher. Additionally, on this form, ‘Small Group Areas’ and ‘Large Group Areas’ were changed to ‘Materials Area’ and ‘Alternative Functional Area.’ The ‘Alternative Functional Area’ includes any space, excluding the student’s desk area, which can be productively used by a student while working on an activity. This may include, but is not limited to, table space, the floor, or space in the hallway. Information obtained by using this form was included in Chapter IV.

The researcher practiced member checking by sharing the observations with the classroom teacher to correct errors and enable the teacher to provide additional information that was unknown to the researcher.

Form #3

A map of the classroom design was prepared for each of the investigated classrooms. The available floor space was calculated and was used with the classroom population to determine classroom density. Data used to create the map were collected during a personal visit to the classroom after the end of the regular school day. A map of each classroom was included in Chapter IV.
Data Analysis

An evaluation of the aggregate data was conducted using a matrix published by NYSED (Appendix G). The application of the matrix was modified to include a larger number of questions in calculations to establish correlations. The standard form of this evaluation has been utilized annually in each school district for the purpose of adjusting the elementary science program.

Test scores for the five classrooms that participated in the study were compared for mean, median, mode, and standard deviation. A T-test for two independent samples was conducted using data from four classrooms to test for the effect of moving a materials table to the center of the room. The data were analyzed using SPSS subprograms. Comparisons were also made to historical data.

The location of the teacher in the room and the movement of students were summarized based on information recorded on the classroom map and the Classroom Migration Form. From this information, areas of non-use could be identified and the amount of student-teacher interaction was inferred.

The classroom map and the Classroom Spatial Utilization Form were used to describe the environment of each classroom. Both quantitative and qualitative data were used to provide a written description and a floor plan for each classroom.

Summary

Chapter III has explained the design of this research study. The quasi-experimental design utilized both quantitative and qualitative data. The quantitative data were obtained from a state-prepared test in science. Qualitative data were
obtained from the Classroom Spatial Utilization and Migration Form. Limitations of the study were discussed. The three forms that were used were described and a plan to analyze the data obtained by using the forms was presented.

Chapter IV will present the data obtained by using the three forms, and discuss ions with the five classroom teachers. Serendipitously, a factor that significantly impacts student achievement is identified. In addition, a new diagram is put forth as a way to think about the interaction of time and space in a classroom.
CHAPTER IV

Presentation of Data

Introduction

In this study, the researcher explored the influence of classroom organization in grade four on student achievement in science. Teachers volunteered in five classrooms in two rural, elementary schools to participate in the study. In two of the classrooms, teachers moved a table to the center of the room to provide a focal point for inquiry-based science activities. Student achievement was measured by using the performance portion of the Grade-4 Science PET. Movement during a science instructional period by students and teachers was recorded on the Classroom Migration Form and on a map of the classroom. The Classroom Spatial Utilization Form was used in conjunction with a classroom map to describe the arrangement of fixed and moveable furniture in the classroom. The data are presented in quantitative, narrative, and graphic forms.
Participants

Letters of solicitation along with background information regarding classroom furniture arrangement were sent to ten grade-4 teachers in the two selected elementary schools. Five teachers agreed to participate in this investigation. Three of the teachers worked in the Indian Lake Elementary School (pseudonym) where one teacher (room #1) agreed to participate if the classroom could be used as a control without receiving the treatment. In room #2, a large table was placed in the center of the room during the 2000 – 2001 school year. Data from this classroom was used as a control to assess increases on test scores that could be attributed to experience with the testing regimen. Furniture in classroom #3 was rearranged so that a large table was placed along one side of the room. This arrangement enabled the teacher to gather all her students around the table at one time and use the chalkboard on the adjoining wall. These teachers had 25, 16, and 12 years of teaching experience respectively.

Two teachers from the Oak Ridge Elementary School (pseudonym) volunteered to participate in the investigation. The furniture in classroom #4 did not include any large tables so this classroom was used as a control. Large tables in room #5 were moved to the front-center of the room. The teachers in the Oak Ridge Elementary School had 5 and 30 years of experience respectively.

When asked how students were placed in homerooms, the principal of each school outlined identical procedures (personal communication, April 10, 2002). Committee on Special Education (CSE) students were first placed in two homerooms in equal numbers. Both of these rooms gained a special education teacher to assist
with making instructional and test modifications for CSE students. Classroom #4 in
the Oak Ridge Elementary School included students with a CSE designation.

Students who qualified for extra support services or remediation were evenly
divided among all the homerooms. Students who require the same kind of support are
often clustered in the same homeroom making it easier for the teacher who provides
the support to meet with the students. Thus, each classroom normally contains five
students who require some form of extra help.

Grade-three teachers recommend the placement of the regular students in a
grade-four homeroom based on the students’ learning style, the teachers’ teaching
style, parent input, and student behavior. Based on these criteria, students assigned to
room #1 typically functioned best in a highly structured environment and possessed
good writing skills. Students assigned to room #3 were likely to function best in a
hands-on environment. In addition, every attempt was made to create a balance in
each room based on age, gender, ability, and behavior. In this way, every class
contained students with a range of abilities and problems. The average age of the
students in each classroom differs by less than two months. Participating classes in
the Indian Lake Elementary School are larger (28, 27, and 26 students) than classes in
the Oak Ridge Elementary School (19, and 22 students). Table 1 shows the
distribution of students in the five rooms in the study.

**Classroom Characteristics and Spatial Utilization**

Information regarding the fixed environment and furniture arrangement was
collected for each of the five classrooms using the Classroom Spatial Utilization
Table 1

<table>
<thead>
<tr>
<th>School</th>
<th>Room #</th>
<th>Gender</th>
<th>Total</th>
<th>Average Age (yr.)</th>
<th>Type</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>M</td>
<td>F</td>
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<tr>
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<td>1</td>
<td>15</td>
<td>13</td>
<td>28</td>
<td>9.90</td>
</tr>
<tr>
<td>Indian Lake</td>
<td>2</td>
<td>13</td>
<td>14</td>
<td>27</td>
<td>9.99</td>
</tr>
<tr>
<td>Indian Lake</td>
<td>3</td>
<td>10</td>
<td>16</td>
<td>26</td>
<td>9.89</td>
</tr>
<tr>
<td>Oak Ridge</td>
<td>4</td>
<td>10</td>
<td>9</td>
<td>19</td>
<td>10.03</td>
</tr>
<tr>
<td>Oak Ridge</td>
<td>5</td>
<td>11</td>
<td>11</td>
<td>22</td>
<td>9.96</td>
</tr>
</tbody>
</table>

Note: <sup>a</sup>(O) = Control Classroom; <sup>b</sup>(X) = Experimental Classroom
Form (Appendix A). Information about each classroom was gathered at the end of the regular school day. Information collected regarding the environment, furniture and the classroom map was shared with the respective teachers for their additions and corrections. A completed Spatial Utilization Form for each classroom is found in Appendix J.

The Indian Lake Elementary School was built in 1959. All classrooms are located on one level of the school building. The fourth-grade classrooms are located on one hallway and are identical to each other. Each classroom had 847 square feet of floor space and ceilings that are 9 feet 2 inches in height. Six operable windows in each room provided a total of 128 square feet of window surface.

The windows in rooms #1 and #3 faced north-northeast and therefore were not exposed to any distracting glare from the sun during the school day. Room #2 faced the south-southwest and was subject to glare from the sun during the afternoon. Awnings located on the outside of the building were not in operation and therefore window blinds were used to block annoying sunlight. Diffused light provided by cool/white fluorescent bulbs also illuminated the rooms.

Different color schemes are used in each classroom. Subdued colors were used both for the floor tile (green, rust, and mud brown) and the wall paint (light blue, and cream). Color was not considered as a variable in this study.

Storage was provided in a variety of ways. Teachers had a closet, shelves and a file cabinet for personal materials. Students had individual storage space in their desks and communal storage space in areas adjacent to the coat rack. Class materials are stored in closets, on shelves, and in bins.
A radiator that ran the length of the wall and under the windows provided heat. There was no system to provide air circulation (heating, ventilation, air-conditioning or HVAC systems) so teachers frequently use fans in the classroom during especially warm weather.

Each classroom contained some built-in fixtures. A 2’ x 4’ counter equipped with a double sink adjoined two 2’ x 4’ open cabinets with coat hooks and area to store student backpacks. The space did not provide sufficient storage area for student belongings and therefore the backpacks tended to occupy a portion of the adjoining floor space. The teachers used an adjacent 2’ x 4’ storage closet for class materials.

Moveable furniture was in every classroom. Each room contained a file cabinet, teacher’s desk, waste paper can, overhead projector cart, five computers, shelves, and student desks. Each student desk contained a storage area under the top work surface. A separate chair was used at each desk. Metal cabinets, plant stands, storage bins, stools, magazine racks, easels, hanging charts, and a map storage table are also found in the rooms.

Work areas are similar in each of the three rooms. Students are able to work on their desks and at small and/or large tables. Each teacher had a desk for a work area.

In room #1, 79 square feet (sq. ft.) of floor space was reserved for teacher use, or 9% of the total floor space of the classroom. Twenty-eight student desks and 27 other pieces of furniture occupied 225 sq. ft. of floor space (27%). Open space amounted to 543 sq. ft. (64%).
In room #2, the teacher has reserved 75 sq. ft. of floor space for her use (9%). Twenty-nine student desks and 22 other pieces of furniture occupy 262 sq. ft. of floor space (31%). Open space amounts to 510 sq. ft. (60%).

The teacher in room #3 has reserved 61 sq. ft. of floor space for her use (7%). Twenty-eight student desks and 15 other pieces of furniture occupy 175 sq. ft. of floor space (21%). Open space amounts to 611 sq. ft. (72%).

The Oak Ridge Elementary School was built in 1991. The two-story, triangular building had an interior courtyard. Grade-4 classrooms are located on the second floor. The two participant classrooms were on opposite sides of the hallway. While the rooms shared a basic floor plan, the dimensions of each room were slightly different: room #4 had 777 sq. ft. of floor space while room #5 had 799 sq. ft. of floor space. Ceiling were nine feet high. Both classrooms had five operable windows, which provided 73 sq. ft. of window surface. The windows in room #4 faced south-southeast and therefore were exposed to a distracting glare during the morning hours. Room #5 faced north-northwest and therefore was not subjected to any distracting glare from the sun. Diffused light provided by cool/white fluorescent bulbs also illuminated the rooms.

Different color schemes were used in each classroom. Bold colors were used in the carpet (dark blue, and dark green) and on the back wall of the room (dark blue, and dark teal). The other three walls in both rooms were painted off-white.

Heat and air circulation was provided by an HVAC system located under the windows. The system provided heat on demand and drew air into the room from the
out-of-doors. Central air conditioning was not connected to these systems at the time of the study.

Storage is provided in several ways. Both teachers have shelves, a cabinet, and a file cabinet. In addition, the teacher in room #4 has a coat closet. Personal storage areas for students are identical in both rooms. The students have a desk, shelves, tables, a coat rack, and a cubby for their use. General use materials are stored in a closet, on shelves, or in bins.

Each classroom contains some built-in features. Each room contains a 2' x 6 1/2' counter area that features two sinks, a 2' x 4 1/2' storage cabinet, storage cubbies with a coat hook for each student, and two bathrooms that were accessible by students in the adjoining classroom. The original attempt to designate a boy's room and a girl's room resulted in several embarrassing moments when the door was opened by a student from the adjoining classroom only to find the facilities were in use. Teachers quickly decided it was better for each classroom to lay claim to one unisex bathroom. Consequently, one bathroom doorway had been blocked with a heavy piece of furniture.

As in the Indian Lake Elementary School, moveable furniture was located in both classrooms. Each room is equipped with a file cabinet, teacher's desk, waste can, overhead projector cart, computers, and student desks. Rolling shelves, a rolling bulletin board, storage bins, and cabinets were also in the classrooms.

Work areas are similar in both rooms. Students in both rooms are able to work at their desks and at large tables. In addition, room #4 has small tables. Teachers in both rooms have a teacher's desk.
A summary of the characteristics of the classrooms participating in the study is found in Table 2. It should be noted that teachers tend to keep surplus student desks in their rooms.

In room #4, 57 sq. ft., or 7% of floor space, was reserved for teacher use. The 27 student desks and 22 other pieces of furniture occupy 226 sq. ft. of floor space (29%). Open space amounts to 494 sq. ft. (64%).

In room #5, 50 sq. ft. of floor space was reserved for teacher use (6%). Twenty-eight student desks and 17 other pieces of furniture occupied 185 sq. ft. of floor space (23%). Open space amounts to 564 sq. ft. (71%).

A summary of floor space usage is found in Table 3. The two experimental classrooms had the greatest amount of open floor space. The total floor area is less in room #5 (799 sq. ft.) than room #3 (847 sq. ft.) but the teacher in room #5 uses the smallest amount of floor space (50 sq. ft.).

Classroom Observations

Classroom observations were conducted during April and May 2002, at the convenience of the teacher and the researcher. All observations occurred between 11:00 AM and 1:00 PM. A science lesson was observed during the classroom visit. The researcher used the Classroom Migration Form and a map of the classroom during each observation. Having been in the classroom on several occasions before the data-gathering visit, students were accustomed to having the researcher in the classroom. Thus, there was no contact between the researcher and the students during
Table 2

Characteristics of Classrooms Participating in the Study

<table>
<thead>
<tr>
<th>Room #</th>
<th>Student Desks</th>
<th>Fixed Units</th>
<th>Moveable Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (O)</td>
<td>28</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>2 (O)</td>
<td>29</td>
<td>3</td>
<td>22</td>
</tr>
<tr>
<td>3 (X)</td>
<td>28</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>4 (O)</td>
<td>27</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>5 (X)</td>
<td>28</td>
<td>3</td>
<td>17</td>
</tr>
</tbody>
</table>

Architectural Features by Classroom

<table>
<thead>
<tr>
<th>Room #</th>
<th>Window Area Sq. ft.</th>
<th>Direction</th>
<th>Floor Color</th>
<th>Wall Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (O)</td>
<td>128</td>
<td>NNE</td>
<td>Green</td>
<td>Cream</td>
</tr>
<tr>
<td>2 (O)</td>
<td>128</td>
<td>SSW</td>
<td>Rust</td>
<td>Lt. Blue</td>
</tr>
<tr>
<td>3 (X)</td>
<td>128</td>
<td>NNE</td>
<td>Mud Brown</td>
<td>Cream</td>
</tr>
<tr>
<td>4 (O)</td>
<td>73</td>
<td>SSE</td>
<td>Dk. Blue</td>
<td>Off-white/Dk. Blue</td>
</tr>
<tr>
<td>5 (X)</td>
<td>73</td>
<td>NNW</td>
<td>Dk. Green</td>
<td>Off-white/Dk. Teal</td>
</tr>
</tbody>
</table>

Note: *(O) = Control Classroom; *(X) = Experimental Classroom*
Table 3
Classroom Areas: Teacher Area, Furniture Area, and Open Space

<table>
<thead>
<tr>
<th>Room #</th>
<th>Floor Area Sq. Ft.</th>
<th>Teacher Area</th>
<th>Furniture Area</th>
<th>Open Space</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sq. Ft.</td>
<td>%</td>
<td>Sq. Ft.</td>
</tr>
<tr>
<td>1 (O)^a</td>
<td>847</td>
<td>79</td>
<td>9</td>
<td>225</td>
</tr>
<tr>
<td>2 (O)</td>
<td>847</td>
<td>75</td>
<td>9</td>
<td>262</td>
</tr>
<tr>
<td>3 (X)^b</td>
<td>847</td>
<td>61</td>
<td>7</td>
<td>175</td>
</tr>
<tr>
<td>4 (O)</td>
<td>777</td>
<td>57</td>
<td>7</td>
<td>226</td>
</tr>
<tr>
<td>5 (X)</td>
<td>799</td>
<td>50</td>
<td>6</td>
<td>185</td>
</tr>
</tbody>
</table>

Note: ^a(O) = Control Classroom; ^b(X) = Experimental Classroom
the class period. Only one visit was made to each classroom for the purpose of gathering data regarding student and teacher movement during a science class. The movement of each student was recorded on a map of the classroom. In addition, the location of the teacher was noted at two-minute intervals (Appendix I).

Classroom Migration

A science lesson was observed in room #1 for 28 minutes. The time period began with all students at their desks. Within four minutes, all the students retrieved materials for finishing their ecology reports and posters and gathered in functional groups of three or four using alternative functional settings (100%). Some students hung their unfinished posters on the chalkboard while others spread out their materials on the floor. One group used the space on two small tables located in the back of the room while another group made a circle of four chairs to rehearse their presentation. Other students used word processing programs on the computers. Four minutes before the end of the allotted time, a group of students used a cluster of student desks as a large table. The teacher desk area was not used during this lesson.

The furniture in the room had been rearranged since my last visit. All the student desks had been moved into two large clusters. One cluster contained 14 desks while the other had 15 desks. The teacher reported that she had settled on this arrangement to create more open space on the floor so students could work on their projects, as many of the posters were larger than 20 square feet. The large open spaces created broad walkways for students as they moved to meet with their project group. Students moved freely about the room as they gathered materials and looked to
the teacher for advice. The teacher moved around the room to assist each group with their work.

A hands-on science lesson was observed in room #2 for 26 minutes. During the first four minutes of class, successive students (4% of class) used an alternate functional area (chalkboard). For the next 20 minutes, groups of six or seven students worked on a directed inquiry activity at a large table containing materials (magnets, scissors, and paper clips) needed for a magnetism activity. This represents 22% - 26% of the students. At the same time, one or two students (4% - 7%) worked on a directed inquiry activity (electrical conductors) located on a table in the front of the room. During this time, over 70% of the students were at their desks. The hands-on portion of class was concluded with all students working at their desks. The teacher desk area, located in the rear of the room, was never used during this lesson. The teacher moved to different positions across the front of the room during the time of observation.

A map of migration patterns in room #2 shows that each student moved from his/her seat to the large table in the center of the room. Three students went to the coat rack area. Students who went to the chalkboard and those who left and reentered the room heavily used a pathway in the front of the room between a large table and student desks. Pathways on the sides of the room were seldom used. Floor space in the back of the room and a carpeted reading area in the front of the room were not used.

The science lesson in room #3 was observed for 50 minutes. In the first few minutes of class some students moved to a different seat in order to work with a
favored partner and in some cases, desks were moved to create a better work area.

Two students (8%) moved from their student desks to a small teachers desk that had been previously used by a student teacher. One student from each pair (50%) went to a pair of large tables that had been placed on one side of the room to pick up materials needed for a challenge inquiry activity (paper plate, 40 mini-marshmallows, toothpicks, and a sheet of 1 cm. ruled graph paper). All of this was accomplished in the first six minutes of class. Students worked at their desks (92%) or at an alternative functional setting (8%) for the next 36 minutes planning and building as tall a structure as they could that would stand overnight. Without fail, the pairs of students sat next to each other as they worked to create their structure. During the last eight minutes of class, students moved their structure to the long tables on the side of the room and then returned to their regular desk. The teacher desk area was never used during this class period.

Movement by students in this classroom was extensive. One-half of all the students went to the long tables to pick us materials at the start of class and virtually all students returned to the same area at the end of class with their final structure. In addition, a few students went to the waste paper can, pencil sharpener, sink, coat rack, and paper storage areas during the class time. Students tended to use a pathway next to the large tables and across the middle of the room a great deal. The two students who were using the student teacher’s desk and students sitting on the north northwest end of two clusters of desks were the only ones to use a pathway across the rear of the room. A carpeted reading area, the teacher’s desk area, space between the long table and the chalkboard, and an area adjacent to the chalkboard in the front of the room
were seldom used. The teacher walked around the room for the entire class time helping students with their project.

A science lesson was observed in room #4 for 16 minutes. Because this is a class with a high number of CSE students, a special education teacher worked in the room with the regular classroom teacher. Materials (magnets) were distributed and collected twice by the teacher during the 16-minute period. The student desk area was the only portion of the room used during this lesson.

Since the first visit to this classroom, the furniture arrangement had been changed three times. Previous to this visit, 21 student desks were arranged in three clusters. For this visit, the 21 desks were arranged in five clusters.

Students (100%) remained at their desks during the entire class period. Movement in the classroom was confined to four students (18%). Three students moved from their seats to share materials found at a neighboring cluster. One student used the sink area to wash his hands. Sharing responsibility for the students, the two teachers moved between tables to monitor the student activity.

A science lesson in room #5 lasted 50 minutes. Students began by sitting on the floor around the outside of the classroom or on a bench in front of the coat racks. Materials for four different kinds of activities (grouping, measurement of mass, measurement of liquids, and insulators and conductors) had been arranged on the students' desks. Fourteen students (64%) were assigned positions at the three clusters of desks and a front table that was adjacent to one cluster of desks. As a student completed a guided inquiry task at the station, he/she traded places with a student from the side of the room who had been working on a reading and writing activity.
This process was repeated over and over enabling students to rotate at their own pace among the four stations and the side of the room. In the first 36 minutes of class, most students completed the ‘grouping’ activity and were waiting a turn at one of the remaining three stations. The class ended with students helping to package the materials at the stations and returning them to a bin at a central materials area.

The map of migration patterns shows extensive use of the open space in this room. The four science stations were arranged across three clusters of student desks necessitating that students move extensively around the room. Pathways in the back of the room were heavily used, as was the bench area at the coat rack. The teacher was in constant motion around the room assisting students with the activity and continually assigning students to stations.

All areas of the room are not equally used as student pathways. A graphic display of student migration in each classroom is found in Appendix K.

Overall, certain patterns can be deduced when considering the five migration pattern maps and their graphs together. Initial movement of students from their normal seating pattern to a new configuration for the science activity took place within four minutes. That new configuration was maintained for the duration of the activity. During the remainder of the class period, students switched places with other students, gathered supplemental materials, or moved to speak with the teacher. These movements frequently occur in less than two minutes. Thus, the movement is recorded on the migration map but the movements are masked on the graph.

Additional information can be noted when the migration patterns are diagrammed on a classroom map for the five classrooms and then considered in total.
(Appendix L). The front of the room was used for lateral flow patterns. Placing a large piece of furniture, or a row of desks parallel to the flow pattern, in the front of the room served to impede traffic flow and caused pedestrians to be diverted into the aisles (e.g., rooms #1, 2, and 3). In all classrooms, major aisles were perpendicular to the front of the room regardless of the clustering arrangement used. When the aisles were broad, they invited student traffic. When student desks or tables were parallel to the front of the room, smooth patterns of pedestrian movement are interfered with and efficiency of flow was reduced. Broad areas invited pedestrian traffic. On the other hand, narrow pathways between desks were used by only a few students and frequently could be used only for one-way traffic. Furniture larger than a student’s desk that was not placed against a wall tended to create open space between the furniture and the wall that was seldom used (e.g., rooms #2, 3, and 4). Empty corners of the room are devoid of student traffic. In addition, the area around the teacher’s desk is never entered.

Migration patterns and the accompanying graphs show the interrelationship of three elements that teachers can control: time, space, and student-teacher interactions. The area near the entrance to the classroom — always at the front of the room in this study — is used for a lateral flow pattern. Broad aisles perpendicular to the front of the room invite students to walk toward the back of the room. Desks and tables placed in the front of the room and parallel to the lateral flow pattern impede pedestrian movement.
Feedback from Member Checking

Following each classroom observation, the researcher meet with the classroom teacher to review observations that had been made. The movement of students as shown on a classroom map was shared and discussed. Invariably, the teachers made comments that could be categorized under a few common themes: seating arrangements, storage, center of the room, student work areas, the teacher’s desk, and student desks vs. tables.

Seating arrangements.

(Room ID followed by comment).

(#1) The seating arrangement is often based on the personality of the kids. I find that clusters work well with kids that cooperate. I sometimes use a square format to use the middle of the room as a meeting space for students or a ‘teacher talking’ space.

(#2) I use tables in the middle of the room for three reasons: 1) for reading groups and so I can see the whole room at once; 2) it keeps potential discipline problems apart; and 3) I need a science table in the front of the room so kids see the importance of science.

(#3) I always ask myself, “What are the next activities? What is the best arrangement for that activity? What space will the kids need? They need space to see the teacher and small group space. Are large spaces or small spaces needed? The large tables become the focal point no matter where I put them. I used to change the desks. Now I change the tables. The tables are used for reading and writing. This has
worked better for me than arranging the chairs. If you are doing demonstrations, they must be done high for the kids to see it. I also pay attention to distractions and make allowances for the students who are claustrophobic.

(#4) I tend to create smaller groups because of the inclusion. I try to sit inclusion students near each other even if they are in different clusters so the resource teacher can get to them without walking the entire room. I have IEP kids who need to be near the chalkboard because of eyesight problems. I also have to consider distractions that may be caused by people in the hall.

(#5) Visibility of the board is a big issue for me. It seems that no matter what I do, I always have my back to someone. I use my clusters as reading groups.

Storage.

(Room ID followed by comment).

(#1) The room is old and dirty. We really need some new furniture that includes places to put things.

(#2) The best thing since sliced bread is containers for $1.99, $2.99, and $4.99 that can be stacked up. The desks are too small for the stuff the kids have. The closets are designed for 10 kids. Lunches get squished and juice boxes get stepped on.

(#3) When kids are asked how they would redesign the room, they suggest that the entry be like a mudroom like they have at home. Space is a problem. I would like to see them leave two computers in the room and move the rest to a lab. Only a couple of the computers are used at one time anyway. It’s a waste of space.
(#4) Finding the space to display student work is really important and a real problem.

(#5) I wind up purchasing bins to put on top of the cabinets. I still have used every inch of storage space that is available.

Center of the room.

(Room ID followed by comment).

(#1) The center of the room is not important. The important thing is to change the focal point. Students respond to newness and having a fresh start. You need to have new places that draw students’ attention.

(#2) The center of the room is very important. That’s why I keep this setup every year. This set-up supports my program.

(#3) People gravitate to an activity center no matter where it is located. A long table in the middle of the room would be good if there were fewer kids. I have thought about moving my long table so it would run lengthwise in the middle of the room and toward the front.

(#4) The overhead dictates where kids sit. The space between the desks helps with teacher movement. The desks should be on wheels.

(#5) Having science in the center of the room would be nice but it moves kids to the side. That makes looking at the board hard for math.
Student work areas.

(Room ID followed by comment).

(#1) If given a choice, students go to work on the carpet. I guess it’s just a comfortable place to be. Their desk is associated with daily work so that is not where they go if they have a choice.

(#2) They want to be out of their seats. On the carpet. On the floor is where they want to be. Sitting on the floor, they think they can’t be seen.

(#3) The kids love to work at the long table, the teacher aide’s desk, on the rug, or in an open space in the front of the room. Rarely do the kids go out in the hall. That’s too far away from the action. They will find a little corner to sit in and read.

(#4) Kids love to work on the floor or in the hall. I also find them trying to get to a private space.

(#5) Some of the kids work best alone so they are trying to find corners or places behind the bookcases.

Teacher’s desk.

(Room ID followed by comment)

(#1) I don’t use my desk that much. Mostly it is a place for storage. I work mostly at the table in the front of the room. I would trade my desk for a bookshelf with doors.

(#2) I use my desk very little. During the day I can’t use it. I sit at the center table. I do use it at 3:30, when the kids go home, to correct papers, do plans, and do office kind of work. I never use it during teaching. You need a place for your
personal space. It's a place for your stuff. It's a sacred area where no children are allowed.

(#3) My desk is used for storage. It houses paper. The best furniture for me is on wheels. Then you can move it around and out of the way. I don't need a desk.

(#4) It is not a part of my teaching. It's a place to do the stuff I don't like. I only use my desk before and after school.

(#5) I use my desk just for grading student papers and making plans.

Student desks vs. tables.

(Room ID followed by comment)

(#1) The desks I have are all different sizes. It's hard for students to work together on a project when the desks are not the same height. I don't see tables as being an answer. The students need a place to put their pencils and where do you put the books?

(#2) Using tables would double the storage needs. Wire baskets under the desk for storage could work.

(#3) Big tables would help if I had the room. How do I get more space?

(#4) Tables wouldn't work for me.

(#5) I was in a school one year where all I had were tables. It was awful. The students didn't have a place to put their personal stuff. If all the storage were on the side of the room, students would waste a lot of time getting their materials and getting back to their tables. I don't have time to waste like that.
Classroom Links to Time and Space

Together, the data collected from the Classroom Spatial Utilization and Migration Form and the classroom map combine to create an adumbration that shows the interaction of time and space. Classrooms with a small amount of space per student were prone to have inefficient pathways. In part, this situation was caused by the large amount of room teachers reserved for their own use and the large amount of floor space covered by other pieces of furniture. The arrangement of the furniture hampered natural flow patterns and created small open spaces that were not useful as alternative places for students to work. Thus, teachers more or less identified and assigned the spaces that were to be used by the students while working on an activity.

The use of space was also reflected in the use of time (Figure 1). Every teacher expressed the need to work in a specific time frame (m-time) when giving instructions to the class.

Space use in classrooms #1, #3, and #5 demonstrated a shift toward a high context class environment (Figure 2). Large open spaces provided broad pathways for ease of movement and offered students alternative areas to spread out and work.

This use of space enabled students to be doing several different things at the same time. The focus of the teachers was on continuous involvement of all students and enabled students to conduct conversations with the teachers. Teachers continued to keep an eye on the clock but students were better able to control their own use of time.
Figure 1 - Classroom Links to Space and Monochronic Time

Note: a A time frame in which single events are scheduled generally in serial order.

b Inefficient use of space limits students to identical tasks.

(Key Concepts adapted from the seminal work of E.T. Hall, 1976)
Figure 2 - Classroom Links to Space and Polychronic Time

Note: "A time frame in which several activities occur at once.

"Broad, open spaces permit students to pursue individual learning activities.

(Key Concepts adapted from the seminal work of E.T. Hall, 1976)
Historical Data

Form Z of the exam was first administered in the year 2000. Thus, only two years of historical results were available for the five selected classrooms. A comparison of scores is found in Appendix M. It would be expected that the scores would go up slightly because teachers would be more familiar with the test in 2001, than in 2000, and therefore in a better position to prepare students for the exam. Program scores are the average class results for all five stations of the performance test. Student scores are the average results for the three stations that individual students completed.

Comparing the program scores between the years 2000 and 2001, the scores in classroom #1 increased by 2.9 points (34.8, 37.7). It should be noted that this classroom teacher sent her students to room #3 to receive their instruction in science during the 2000-01 school year. Program scores increased in room #2 by 7.1 points (30.4, 37.5). In room #2, the teacher rearranged the classroom several years ago by placing a large table in the center of the room. In part, this was done to separate some students with behavioral problems. Program scores in room #3 dropped 0.5 points (35.4, 34.9) points. Program scores in room #4 decreased 1.2 points (31.2, 30.0). The scores in room #5 increased by 1 point (34.9, 35.9). Class size ranged from 23 to 26 in the Indian Lake Elementary School with an average of 24.6. Classes in the Oak Ridge Elementary School ranged in size from 22 to 24 with an average of 22.5.

Comparisons of the average student scores in each room show little change. In fact, the variation between 2000 and 2001 is less than the standard deviation in every case. Student scores in room #1 increased by 2.0 points (20.7, 22.7). Student’s scores
in room #2 increased by 3.3 points (19.2, 22.5). In room #3, student scores decreased by 0.9 points (22.3, 21.4). Scores also decreased in room #4 but at a smaller level (-.04; 19.5, 19.1). In room #5 the student scores did not change.

Summaries of results by room using the state matrix (Appendix H) are found in Table 4. Percentages for the key ideas and the skills vary greatly because the achievement level on each key idea and skill is based on a small number of questions. The five key ideas are based on a total of 21 questions (key idea 1.3, 5 questions; key idea 2.3, 5 questions; key idea 3.1, 3 questions; key idea 3.2, 3 questions; and key idea 3.3, 5 questions). The seven skills are based on a total of 32 questions (classifying, 4 questions; inferring, 6 questions; interpreting data, 3 questions; manipulating material, 8 questions; measuring, 4 questions; observing, 4 questions; and recording data, 3 questions). There are only two questions on Form Z related to communicating, generalizing, predicting, questioning, and using non-standard measurement. Thus, there are too few questions to establish a state minimum achievement level.

The skills can be divided into two groups: hands-on skills and thinking skills. Classifying, manipulating materials, measuring, observing, recording data, and using non-standard measurements comprise the group of hands-on skills. The thinking skills consist of communicating, generalizing, inferring, interpreting, predicting, and questioning.

Using data from 2000, the six hands-on skills (25 questions) were considered as a package and correlated to the number of square feet of space per
Table 4

**Percentage of Items in Key Ideas and Skills Below State Minimum Level, 2000 - 2001**

% of Items Related to Key Ideas in Standard #1 – Scientific Inquiry below the State Difficulty at Minimum Achievement Level

<table>
<thead>
<tr>
<th>Key Idea</th>
<th>1 00&lt;sup&gt;b&lt;/sup&gt; 01&lt;sup&gt;a&lt;/sup&gt;</th>
<th>2 00 01</th>
<th>Room #</th>
<th>3&lt;sup&gt;a&lt;/sup&gt; 00 01</th>
<th>4 00 01</th>
<th>5&lt;sup&gt;a&lt;/sup&gt; 00 01</th>
</tr>
</thead>
<tbody>
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<td>40 20</td>
<td>60 80</td>
<td>0 20</td>
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</table>

% of Items in Skill Area below the State Difficulty at Minimum Achievement Level

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<th>Room #</th>
<th>3&lt;sup&gt;a&lt;/sup&gt; 00 01</th>
<th>4 00 01</th>
<th>5&lt;sup&gt;a&lt;/sup&gt; 00 01</th>
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<td>75 50</td>
<td>50 25</td>
<td>75 100</td>
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<tr>
<td>Inferring</td>
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<td>14 0</td>
<td>14 0</td>
<td>14 0</td>
<td></td>
</tr>
<tr>
<td>Interpreting Data</td>
<td>0 0</td>
<td>33 0</td>
<td>33 0</td>
<td>33 0</td>
<td>33 0</td>
<td></td>
</tr>
<tr>
<td>Manipulating Material</td>
<td>38 25</td>
<td>38 38</td>
<td>38 38</td>
<td>25 50</td>
<td>0 25</td>
<td></td>
</tr>
<tr>
<td>Measuring</td>
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<td>0 0</td>
<td>0 25</td>
<td>0 0</td>
<td>0 0</td>
<td>0 0</td>
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<td>Observing</td>
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<td>25 50</td>
<td>25 0</td>
<td>50 75</td>
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<tr>
<td>Recording Data</td>
<td>0 33</td>
<td>66 33</td>
<td>66 33</td>
<td>0 100</td>
<td>33 67</td>
<td></td>
</tr>
</tbody>
</table>

Note: <sup>a</sup>Experimental room in 2002; <sup>b</sup>00 = 2000; <sup>c</sup>01 = 2001
student in the five participating classrooms. In this sample of 120 students, there is a very high positive correlation between student grades achieved in the hands-on skills of the grade-4 science PET and the number of square feet of space per student in each classroom (Hinkle, Wiersma & Jurs, 1998). The correlation is significant at the .05 level. When the class mean score for each of the 25 questions that combine to form the hands-on group of skills was totaled and compared to the square feet of space per student in each classroom, there was a Pearson correlation coefficient of +.910 that was significant at the .032 level (2-tailed) \( r = +.910, p = .032 \). This means that in classrooms that have greater amounts of open space per student, on average, student scores are higher on the 25 questions dealing with hands-on science skills.

When average student grades by classroom for the six thinking skills (17 questions) are correlated to the number of square feet of space per student in each classroom, a correlation of +.505 is observed but it is not significant \( (p = .385) \). This means that the amount of open classroom space per student is not related to student achievement on the 17 questions dealing with thinking skills found on the grade-4 science PET.

This implies that 83% of the variance in student grades on the hands-on skills found on the grade-4 science PET can be substantially accounted for by the number of square feet of space per student in each classroom.

Using data from 2001, there is no significant correlation for either the hands-on skills \( (r = +.076, p = .903) \) or the thinking skills \( (r = -.193, p = .756) \) groups when compared to the number of square feet of space per student in each classroom.
This inconsistency in correlation when using the data from 2000 and 2001 contributed to the researcher decision to pursue the present study.

**Test Administration - 2002**

The Grade-4 Science Program Evaluation Test was administered at the Indian Lake Elementary School and the Oak Ridge Elementary School on May 15, 2002. The exam was administered in a similar manner in each school. Testing took place in the school gymnasium during a 1-hour block of time. One teacher was in charge of the test site and he/she read the instructions, from a manual provided by the state, for all the students in that school. Paraprofessionals at each site help by setting up materials, cleaning water spills at station #1, replacing defective materials, and assisting teachers in the overall management of the exam.

Materials used for the test are uniform across the school district. The Board of Cooperative Educational Services (BOCES) #2 in Monroe-Orleans Counties had packaged the needed test items and sold them to school districts throughout the state. The School District used those materials in each of its four elementary schools.

The placement of students at the testing stations was random. Prior to the exam, the students filled out information required on the front cover of the student test booklets: student name, school, city, teacher name, gender, and date. Paraprofessionals put the student test booklets in random order and assigned students to a test station.
Fifteen minutes were allotted for students to complete the task at each station. While no clock was visible to the students, the lead teacher informed students when they had five minutes left and again when two minutes of test time remained.

The testing site was set up differently in each school. One side of the divided gymnasium was set up with five rows of three tables in the Indian Lake Elementary School. Stations #1 and #5 occupied one table, stations #2 and #4 occupied a second table, and the third table was used for station #3 where two students worked together on the same problem. Each test station was provided with a metal folding chair. One class at a time was tested in this set-up. Students who required special testing modifications used two complete set-ups on the opposite side of the gymnasium. Two regular teachers, one special support teacher, and two paraprofessionals provided supervision. This test site was uniformly quiet. At the Oak Ridge Elementary School, the entire gymnasium housed eight sets of testing stations. Stations #1 and #2 consisted of two student desks placed together to form an 'L'. This was done to provide students with an area to work with the materials and still have space to spread out their open test booklet. Stations #4 and #5 were at individual student desks.

Station #3 utilized a table. Each testing station was provided with a standard student chair. Students who required special testing modifications were grouped together in one testing cluster. Two classes were tested at one time in this setting. Three regular teachers, one special education teacher, and three paraprofessionals provided supervision. Teachers noted that the gymnasium had been unusually noisy during the morning testing when large numbers of students requiring testing modifications were
present. Several students had the directions read to them and that elevated the noise level.

**Results of the Grade-4 Science PET**

The arrangement of classroom furniture has a significant effect on student achievement but not in a way that was anticipated. With a maximum test score of 27, the mean test score in two control classrooms (#1 and #4) was 21.0 with a standard deviation of 4.7. The mean test score in the two experimental classrooms (#3 and #5) was 22.3 with a standard deviation of 4.7. The result is not significant when the student scores \( N = 47 \) from two control classrooms (#1 and #4) are compared to the student scores from two experimental classrooms (#3 and #5) using a T-test for two independent samples (result was \( p = .710 \)) (Appendix N). When compared to the room results for 2001, the change in the class average is near or less than one standard deviation. In fact, the average score decreased in rooms #1 and #2. An increase in student scores that can be attributed to the placement of a table in the center of the room or to increased familiarity of teachers with the exam format is not statistically supported. A summary of the test results is found in Table 5.
Table 5

**Mean, Median, and Mode Scores for Form Z, 2002, by Classroom**

<table>
<thead>
<tr>
<th>Room</th>
<th>1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>2&lt;sup&gt;a&lt;/sup&gt;</th>
<th>3&lt;sup&gt;b&lt;/sup&gt;</th>
<th>4&lt;sup&gt;a&lt;/sup&gt;</th>
<th>5&lt;sup&gt;b&lt;/sup&gt;</th>
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<tr>
<td>Mean</td>
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<td>20.1</td>
<td>22.9</td>
<td>22.1</td>
<td>21.4</td>
</tr>
<tr>
<td>Median</td>
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<td>20</td>
<td>23</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>Mode</td>
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<td>19, 24</td>
<td>22</td>
<td>18, 26</td>
<td>24, 25, 26, 29</td>
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<td>Standard Deviation</td>
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<td>3.91</td>
<td>5.90</td>
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<tr>
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</tr>
<tr>
<td>N</td>
<td>28</td>
<td>27</td>
<td>26</td>
<td>19</td>
<td>22</td>
</tr>
</tbody>
</table>

*Note: <sup>a</sup>Control Classroom; <sup>b</sup>Experimental Classroom*
An analysis of the exam results using the state matrix is found in Table 6. It should be noted that the results for all the classrooms are similar. Analyzing the exam by using this matrix does not show how the classrooms are different.

Disaggregating the test results to evaluate student use of science process skills used in inquiry science activities leads to a better picture of student achievement and interaction with the classroom. The part scores from the Grade-4 Science PET are found in Table 7. In a large sample (N = 122), there is a positive correlation between test scores and student density (sq. ft./pupil). The student density in the five participating classrooms is presented in Table 8. When the test score was compared to student density, there was a correlation coefficient of +.161 and p = .077. This shows little if any correlation (Hinkle, Wiersma & Jurs, 1998). The correlation is not significant because p = .077 is not within the p = .05 level set for this study.

The 12 science process skills incorporated into the exam were each correlated to the student density. The results are reported in Table 9. By themselves, none of the 12 skills had a correlation coefficient that is significant at the .05 level.

However, collectively, six science process skills exhibit a substantial correlation. The skills of classifying, manipulating materials, measuring, making non-standard measurements, recording data, and questioning are positively correlated to student density. Collectively, these six skills are identified through a total of 23 questions. When the total of the class mean scores for each of the 23 questions is combined to form a group of skills and compared to the square feet of space per student in each classroom, there was a Pearson correlation coefficient of +.881 that
Table 6

Percentage of Items in Key Ideas and Skills Below State Minimum Level, 2002

% of Items Related to Key Ideas in Standard #1 – Scientific Inquiry below the State Difficulty at Minimum Achievement Level

<table>
<thead>
<tr>
<th>Key Idea</th>
<th>Room #</th>
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<tr>
<td>1.3</td>
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% of Items in Skill Area below the State Difficulty at Minimum Achievement Level

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<th>Skill</th>
<th>Room #</th>
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<td>Interpreting Data</td>
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<tr>
<td>Manipulating Material</td>
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<td>Measuring</td>
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<td>Observing</td>
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<tr>
<td>Recording Data</td>
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Note: *Experimental room in 2002.
Table 7

Part Scores from the Grade 4 Science PET, 2002

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<th>2 (O)</th>
<th>3 (X)b</th>
<th>4 (O)</th>
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<td>2-3a</td>
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<td>1.8</td>
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</table>

Note: *(O)* = Control Classroom. *(X)* = Experimental Classroom
<table>
<thead>
<tr>
<th>Room</th>
<th>Space (sq.ft.)</th>
<th># of Students</th>
<th>sq. ft./student</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>543</td>
<td>28</td>
<td>19.4</td>
</tr>
<tr>
<td>2</td>
<td>510</td>
<td>27</td>
<td>18.9</td>
</tr>
<tr>
<td>3</td>
<td>611</td>
<td>26</td>
<td>23.5</td>
</tr>
<tr>
<td>4</td>
<td>494</td>
<td>19</td>
<td>26.0</td>
</tr>
<tr>
<td>5</td>
<td>564</td>
<td>22</td>
<td>25.6</td>
</tr>
</tbody>
</table>
Table 9

Correlation of Science Skills to Student Density, 2002

<table>
<thead>
<tr>
<th>Skill</th>
<th>$r^*$</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classifying</td>
<td>.027</td>
<td>.966</td>
</tr>
<tr>
<td>Communicating</td>
<td>.499</td>
<td>.392</td>
</tr>
<tr>
<td>Generalizing</td>
<td>-.082</td>
<td>.896</td>
</tr>
<tr>
<td>Inferring</td>
<td>.496</td>
<td>.396</td>
</tr>
<tr>
<td>Interpreting</td>
<td>-.161</td>
<td>.796</td>
</tr>
<tr>
<td>Manipulating Materials</td>
<td>.844</td>
<td>.072</td>
</tr>
<tr>
<td>Measuring</td>
<td>.657</td>
<td>.229</td>
</tr>
<tr>
<td>Observing</td>
<td>.479</td>
<td>.414</td>
</tr>
<tr>
<td>Predicting</td>
<td>.770</td>
<td>.128</td>
</tr>
<tr>
<td>Questioning</td>
<td>.778</td>
<td>.121</td>
</tr>
<tr>
<td>Recording Data</td>
<td>.438</td>
<td>.461</td>
</tr>
<tr>
<td>Using Non-standard Measures</td>
<td>.499</td>
<td>.392</td>
</tr>
</tbody>
</table>

Note: $r = Pearson Correlation Coefficient$
was significant at the .048 level (2-tailed) ($r = +.881, p = .048$). This is a high positive correlation (Hinkle, Wiersma & Jurs, 1998). This means that in classrooms that have greater amounts of open space per student, on average, student scores are higher on the 23 questions dealing with the skills of classifying, manipulating materials, measuring, making non-standard measurements, recording data, and questioning.

When the identified six science process skills are collectively regressed on student density, a significant Beta of .881 is observed. This Beta is significant at the .048 level (Appendix O). This implies that the student density has a positive impact on the collective score for six science process skills. The higher the number of square feet of empty classroom space per student the higher the collective score on six science process skills. Furthermore, based on the adjusted $r$ squared, approximately 70% of the variance on the skills score can be accounted for by the student density. An increase of one square foot of empty space per student should result in an increase of .9 points in the student score on the grade-4 science PET.

**Summary**

Chapter IV has presented the data collected in this investigation. An analysis was made using student test data, the Classroom Spatial Utilization and Migration Form, and a classroom map. Conceptual diagrams were created to show how the major components of this study were interrelated.

Chapter V presents an interpretation of the data and conclusions. Insights gained through the research are presented in a manner that extends the knowledge
base contained in Chapter II. Suggestions are offered to classroom teachers on ways to improve student achievement.
CHAPTER V

Interpretation of the Data

Introduction

The purpose of this research was to study the influence of classroom organization in grade-4 on student achievement in science. Two avenues of approach were used to investigate this purpose: the impact of classroom arrangement on student achievement on the NYS Grade-4 Science PET was evaluated; and spatial utilization and migration were studied in the context of classroom layout. Thus, both quantitative and qualitative methods were employed.

This study was an attempt to determine if the arrangement of classroom furniture has an impact on student achievement in an inquiry based science program. While the influence of classroom layout has been investigated in previous studies, it has never been connected to standards in a specific subject or in a quantitative way.

New knowledge gained in this study may indicate a new approach to classroom furniture layout that will improve student achievement. All teachers may benefit by understanding the influence of classroom layout on student performance.
The descriptive analysis presented here summarizes the study and offers conclusions regarding the impact of classroom organization on student achievement in grade-4 science. Significant recommendations resulting from the study are also presented.

Summary of Study

This study began in February 2002, with a convenience sample of five classrooms whose teachers volunteered to be a part of the study. The heterogeneous classrooms are located in two elementary schools in the same school district. The school district is located 70 miles north-northwest of New York City. A naturalistic approach was taken by gathering information through classroom observations and by sharing with the teachers after each observation the information that was gathered. Quantitative data were obtained from the Grade-4 Science Program Evaluation Test (PET).

Data were collected onsite at three different times. Data found on the Classroom Spatial Utilization Form and a map of each classroom were prepared while visiting each classroom after regular school hours. Classroom observations were conducted during March and April to collect data recorded on the Classroom Migration Form. The Grade-4 Science PET was administered to students in May 2002.
Conclusions: Grade-4 Science PET

The layout of furniture in a classroom has a significant impact on student performance. The proposed hypothesis that placing a large table in the center of the room would result in improved student performance was not supported by the collected and analyzed (two independent sample T test) data at \( p = .05 \) (result was \( p = .710; N = 47 \)).

However, student density was correlated to student achievement (\( r = .161, p = .077; N = 122 \)). This shows little if any correlation of floor space to the average class grade on the grade-4 science PET and it is not significant at the \( p = .05 \) level.

In particular, increasing classroom space per student improves student receptiveness to their hands-on science experiences. Collectively, the hands-on process skills of classifying, manipulating materials, measuring, recording data, and using non-standard units of measurement and the thinking skill of making predictions show a high positive correlation to classroom space (\( r = .881, p = .048 \)). This duplicates the findings using year 2000 data (\( r = .910, p = .032 \)).

When considering the science skills that were positively impacted by increased open classroom space, two items attract attention. The only hands-on skill not included in the above list is the skill of observation. It is also noteworthy that the thinking skill of making predictions is a part of the list of skills that are positively impacted. Perhaps because students have a greater number of opportunities to interact with each other while doing science in a spacious classroom, they have a greater number of opportunities to think about what will happen. They also have the
opportunity to change the conditions surrounding an experiment and then try out their suppositions.

**Conclusions: Classroom Spatial Utilization**

Each of the participating classrooms in this study is a typical, traditional classroom that met standard classroom requirements for window area and floor space. All the classrooms were sufficiently equipped with windows. It is recommended that classrooms have at least 72 sq. ft. of glass (Tanner, 2000a). All five classrooms in this study possessed more window glass than this minimum amount. All the classrooms are average size, between 700 and 900 square feet in area (Tanner, 2000a). Descriptive reports of each classroom appear in chapter IV.

The placement of a large table in the center of the room to serve as a center for science materials was not a particularly important variable in classroom organization in this study. It only took students two to four minutes to gather the materials needed for their work. After that time, the supply table served no practical use until the end of the activity time when materials were returned. Analysis of the data using a T test for two independent samples indicated that having a central materials area had no significant impact on scores for the grade-4 science PET (p = .710; N = 47).

The space that students have to work in seems to be more important than the arrangement of the furniture. When students had the opportunity to select their own space to work in, they demonstrated that the space was important – not where it was located. Classrooms that contained desks that were all the same size enabled students
to place their desks side by side to create a larger workspace. In classrooms that
contained desks of a variety of heights, it was difficult for students to make a large
work area by moving desks together. As a result, students quickly moved to larger
tables, or the floor in order to find a workspace of a suitable size.

The information on classroom density is important and supports Hall (1969)
who said that classroom organization has an impact on the learning climate.
Classrooms with the highest performing students also had the greatest amount of open
space on the floor.

Not every activity lends itself to using the entire classroom. In total, there are
noticeable areas of the room were not utilized in any situation. With open space,
students will make their own decisions about where to work. Students are capable of
exercising their own judgment and using areas that meet their own needs. Students
will work in a space that is appropriate to the size of the materials being used and the
task to be done. Thus, there is a need for teachers to provide a variety of suitable
workplaces in the classroom: desks, tables, and open space on the floor. This
responsibility includes moving the furniture when appropriate because students will
not move the furniture without being told to do so (Gifford, 1976).

A major factor affecting room arrangement and the potential for empty space
is the number of pieces of furniture in the room. Many pieces of furniture – closets,
shelves, tables, and bins – are used for storage. A greater amount of open space would
be achieved if other storage areas in the school building could be used and some
furniture could thereby be removed from the classroom.
Area available for student storage is necessary but insufficient in all the classrooms. Student desks do not contain enough storage for all the students’ books.

One side of the teacher’s desk should be positioned against the wall. This arrangement results in the teacher’s desk area occupying the least amount of floor space. In view of the fact that every teacher in this study reported that they never used their desk during the regular school day, there is no reason to position the teacher’s desk away from a sidewall.

Crowding in a classroom is created in three ways: by adding furniture, creating narrow pathways, or by adding students. Adding an 8’ x 3’ table to a classroom effectively takes away one square foot of empty space from every student in the room. If desks are aligned in rows, many narrow pathways are created which generate an appearance of the room being cluttered with desks. Whenever a new student is added to a classroom, the student comes with a desk that takes up more room. However, when a student leaves, the desk stays behind.

**Conclusions: Classroom Migration**

The classroom migration map shows the movement of the teacher as well as the students. In many instances, the teacher circulated among the small groups that were working in the room. In general, there is no noticeable difference regarding teacher circulation between the control and experimental classrooms. The presence of a table in the center of the room did not seem to affect student-teacher interaction opportunities. The effect of the classroom arrangement may not be so important as the ability of the teacher to interact with groups of students (Langer, 2001). The time
spent with students is important and happens in classes where the teacher walked around (Rice, 1999).

Pathways used by students (Appendix L) often look like a system of highways. While investigating the science of highway design, this researcher visited a civil engineer. J. Taroli (personal communication, April 15, 2002) stated that classrooms are not highways but rather they are parking lots. Guidelines for the design of parking lots equally apply to the design of classrooms (Packard, 1981).

Arranging student desks in clusters eliminates some pathways that are suitable for use by only one student at a time. These one-person pathways serve no other use. When desks are arranged in clusters, the area occupied by these one-person pathways is added to other small areas. When considered in total, the new area may be large enough to serve as a work area for ‘rug rats’ — students who like to work on the floor.

Interaction of Time and Space

A key component of the classroom is the amount of space available for student use. When the space per student is low, classroom interaction dictated by the new national standards for science is difficult to achieve. Classrooms crowded with students and furniture dictate that teachers work in a low-context, monochronic environment. “Crowding is so devastating in its consequences not because it is inherently bad, but because it results in disorganization and disruption of action chains” (Hall, 1976, p. 124). When space is limited, teachers are forced to be time conscious in order to focus on the job at hand and the task of dealing with many students. Thus, there is an interaction between time and crowding.
People differ in their approach to establishing the classroom environment based on the way they deal with time. "High context people also tend to be polychronic; that is, they are apt to be involved in a lot of different activities with several people at any given time..." (Hall, 1976, p. 132). Hall (1976) goes on to state:

To the low-context, monochronic, one person at a time person, polychronic behavior can be almost totally disorganizing in its effect, which is identical in its consequences to overcrowding. Action chains get broken, and nothing is completed. The two systems are like oil and water: they do not mix. (p. 132)

The interaction of time and space undoubtedly affects classrooms in ways that are detrimental to students and learning. "Sitting regimented at desks according to predetermined, fixed schedules is no way to treat a primate capable of running up to 100 miles in one day" (Hall, 1976, p. 179). As a way to create a better setting for student learning, teachers must find ways to increase space per student and organize activities in polychronic time. "Sitting still in confined places is one of the worst punishments that can be inflicted on the human species. Yet this is what we require of students in school" (Hall, 1976, p. 185).

**Recommendations for Future Research**

This study should be replicated using a larger sample size so that the results can be generalized to a broader population. Expanding this area of work will create a research base that is believable and consistent. Classrooms should be divided into control and experimental groups based on being crowded or non-crowded. In addition, a larger number of classroom visits should be included to permit a
researcher to map student migration patterns for a larger set of instructional activities.

Also, increased attention should be paid to student-teacher interactions during the observation periods. The effect of the classroom on students may not be so much based on arrangement as on interactions with other students and the teacher (Langer, 2001).

Because this is the first quantitative study to be conducted in this area, other studies in this same vein should be undertaken. The idea that increasing space per student increases student achievement supports Achilles (1999) whose research measured student achievement in small classes versus large classes. A third study, using a different method that showed positive outcomes from small classes would triangulate this important educational issue.

Teacher education programs need to include some instruction regarding classroom organization. Many teachers report that they received no formal training on how to arrange classroom furniture effectively. Indeed, most teachers learn about organizational patterns by looking into the classrooms of other teachers. Educating pre-service teachers on ways to use space to promote the maximum benefit for students should be a component of university programs (Weaver, 2001).

Teachers need to explore ways to increase the amount of space per student in their classrooms. The benefits of these changes go directly to the students. There are three ways to achieve greater amounts of space for each student. First, teachers should reduce the amount of furniture in their classrooms. Tanner (2000a) recommended that classrooms should have 49 sq. ft./student. None of the participating classrooms approach that value. Removing furniture, thus reducing the
cluttered look of classrooms, would add floor space that would be available for students.

Secondly, reducing the amount of materials that are stored in classrooms would also have a positive impact on increasing the space available for student use. A first step in that direction would be to survey teachers to identify effective methods to reduce classroom clutter. This could easily be accomplished in a faculty meeting (Loughlin & Suina, 1982).

Third, institution of a policy aimed at reducing the number of students per classroom should be considered. Tanner (2000a) recommends that 49 square feet of space be provided per student in a classroom. This means that only 17 students should be in a classroom with 900 square feet of space. In addition, given the data available (Achilles, 1999; Achilles et al., 2001) regarding the benefits of small classes, teachers should consider doing ‘action research’ studies that could support class size reductions in grade 4. Achilles (1999) stated that, “By following uncomplicated but careful procedures, the teacher as scholar-practitioner can provide insights into teaching and learning in classrooms” (pp 39-40). These data should then be brought to the attention of the administration and be accompanied by a request to immediately begin to reduce classroom density by creating smaller classes. Lowering the number of students in a classroom has a large immediate impact on student density, and assuredly on student learning and air quality (Achilles, 1999).

The impact of air quality on student achievement is worthy of study. Each of the science classes observed was conducted during the second half of the school day. Achilles et al., (2001) reported that CO₂ levels increase in classrooms during the
school day and high CO₂ levels result in lethargic behavior on the part of the students and teacher. Behavior certainly impacts student achievement. Therefore, it only makes sense that air quality is correlated to achievement (Achilles, 2001).

The gender of the teacher was not considered in this study but could provide an area for consideration in future research. Four females and one male participated in this study. If the amount of materials stored by each gender differs, this could impact student achievement.

The effect of different color schemes on students should be studied. Grangaard (1995) changed lighting and room color at the same time and discovered changes in students. The rooms in this study used a variety of color combinations. The effect of color alone should be considered in the context of nonverbal communication.

Arranging desks in clusters reduces the amount of space that is used only for student pathways. Teachers should experiment with ways to arrange the students’ desks in new patterns that will meet instructional needs while creating larger open spaces in the classroom. Teachers must take this initiative because students will adjust to the furniture in its present setting rather than move it (Gifford, 1976). Different seating arrangements can affect student-teacher interaction and task attention (Weinstein, 1992).

Teachers should rearrange their classrooms in such a way that at least one side of their desk is against a wall. All the teachers in this study reported that they did not use their desk during the school day. A greater amount of space would be available for student use if the teacher’s desk were moved out of the center of the room.
Research focused on student-generated ideas for redesigning the classroom environment holds the potential for generating valuable insights. Allowing students to design their own environments has the potential to provide insight about spatial arrangements that are best suited for different kinds of work. This idea was proposed by Weinstein (1979) who stated that it might help to question students directly regarding their physical environments.

The interaction of time and space also needs to be investigated thoroughly in regard to specific learning that takes place in different size spaces. Through observation, teachers could be identified as being monochromic or polychromic in their use of time. A post facto study could then be conducted, using previous test results, to investigate the connection of time to classroom space. Teachers tend to do well at planning time but do not expend enough effort in planning space (Howard, 1975).

As part of the literature review for chapter II, a future researcher should investigate whether people at the State Education Department consider the issue of classroom instructional space. Do the recommendations that accompany the grade-4 science program include guidelines for teachers that address the need for suitable areas for students to perform scientific investigations?

Concluding Comments

The material presented here strongly suggests that hands-on science process skills are enhanced in classrooms that have spacious pathways and large work areas. Certainly, measured and observed student behaviors indicate that space is an
important component of the nonverbal classroom environment. The grade-4 science PET results, diagramed student migration patterns, and students' use of empty space suggest that classrooms simply do not have enough space for 'rug rats.'

The conclusions presented above are offered as "food for thought" that may enhance the learning environment in classrooms beyond the five participants in this study. As Achilles (1999) stated, "one place to consider improvement is at the class level" where the change "will directly benefit the young children in schools" (p 2). Teachers must take a new approach to classroom layout and space use to support students. A properly planned environment can positively impact student movement, access to materials, and enhance classroom interactions. Big space matters for small hands.

Every teacher is an architect of his or her own environment. "The arrangement and use of space are parts of the nonverbal communication system of the classroom" (Sommer, 1977, p 174). It is apparent that learning is directly affected by what the space allows. Therefore, teachers must purposely organize space to promote student achievement. If providing more space leads to student improvement of science thinking skills, then it is imperative that teachers immediately create a more spacious classroom environment. Providing more space for students and enhancing student learning can be as easy as throwing out the furniture.

For Michael, the beach in Delaware provided him with a lot of space – and his constructivist brain was in gear.


Simplicio, J. (1999, Fall). A more innovative classroom can be as easy as one, two, three. Education, 183-185.


Appendices
Appendix A

Classroom Spatial Utilization and Migration Form
Classroom Spatial Utilization and Migration Observation Form

School: ____________________________  Room #: ______  Date: ______  Time: ______

Number of Teachers: ______  Number of Students: ______

Physical Characteristics

Classroom

Traditional: ______  Area: ______
Modified: ______  Ceiling Height: ______
Open: ______  Volume: ______
Appearance [1 (poor) – 5 (good)]: ______

Windows

Number: ______  Operable: ______  Inoperable: ______
Distracting Glare: ______  Size: ______  Location (N, S, E, W): ______

Lighting

Bright: ______  Drop: ______  Full-Spec: ______
Normal: ______  Indirect: ______  Cool/White Fluor: ______
Dim: ______  Recessed: ______  Diffused: ______

Floor Covering

Carpet: ______  Color: ______
Concrete: ______
Tile: ______
Wood: ______
Other: ______

Wall Covering

Wood: ______  Brick: ______  Plaster: ______  Color: ______
Fabric: ______  Tile: ______  Cement Block: ______
Teacher Personal Storage

Closet____ Shelves____ File____ Other____

Student Personal Storage

Closet____ Shelves____ Bins____
Desks____ Tables____ Other____

Material Storage

Closet____ Shelves____ Bins____ Other____

Heating/Cooling

Type________________
Ceiling unit____ Radiator____ Window unit____ Floor unit____
Comfort Zone [1(poor) – 5(good)]____

Furniture

Shelving/Storage____ Built-in____ Moveable____

Student Work Areas

Personal desks____ Small tables____ Large Tables____ Study Carrels____

Teacher Work Areas

Teacher Desk____ Table____ Other____

Condition [1(poor) – 5(good)]____

Spatial Characteristics

Teacher Area Square Ft.____ %____
Furniture Square Ft.____ %____
Open Space Square Ft.____ %____
### Classroom Utilization and Migration Form

<table>
<thead>
<tr>
<th>School</th>
<th>Room #</th>
<th>Date</th>
</tr>
</thead>
</table>

#### Key

- **A** – Student Desk Area
- **B** – Teacher’s Desk Area
- **C** – Materials Area
- **D** – Alternative Functional Area
- **T** – Time Intervals
Appendix B

Letter of Solicitation and

Classroom Furniture Arrangement: Background
Letter of Solicitation

Dear Fourth Grade Staff,

As you may know, I am pursuing an Educational Doctorate degree in the Executive Ed. D. program offered in the College of Education and Human Services, Department of Educational Administration and Supervision, at Seton Hall University.

My dissertation topic focuses on the impact of classroom furniture arrangement on student performance as measured on the practical portion of the Elementary Science Program Evaluation Test (ESPET). This research will begin in February 2002 and conclude in May 2002 with the annual administration of the practical portion of the ESPET. The ESPET is a required exam that must be administered to all grade-4 students in New York State. The study will not require any of your time.

To participate in this research, I request that you rearrange the furniture in your classroom to place a focus on activity tables that occupy the center of the room. Because all classrooms are different and contain different kinds and amounts of furniture, there is no one “correct” pattern to follow for classroom organization and therefore I do not have a template for you to follow. It is expected that you will adjust the furniture arrangement during the school year as need dictates. I plan to visit your classroom after regular class time for the purpose of creating a map to show how the furniture is arranged. The Classroom Spatial Utilization and Migration Observation Form will be used to show how students move around the room and with whom they interact (see attached). This will require one additional visit to your room while a science lesson is in progress.

Your participation in this study is voluntary and you may withdraw from the study at any time up to the end of the study without any fear of prejudice or reprisal.

Any and all information is confidential and no individual results will be included in the study. Only aggregate or group data will be reported. No individual will be identified. You may request to view the data and the results.

This project has been reviewed and approved by the Seton Hall Institutional Review Board for Human Subjects Research. The research procedures adequately safeguard the subject’s privacy, welfare, civil liberties, and rights. The Chairperson of the IRB may be reached at (973) 275-2974.

Thank you for your cooperation in this endeavor.

Edward Duncanson
Doctoral Candidate
Classroom Furniture Arrangement: Background

One place to begin the transformation of education is with better use of existing classroom space to provide a nurturing, learning environment (Simplicio, 1999). "The most obvious form of structure is the classroom itself – how you arrange the furniture, select and organize materials, and what you have on the walls. The physical environment conveys strong messages to children from the first time they enter the room. It can reassure them that their classroom is a place where they will feel safe, comfortable, and where they will do interesting things" (Bickart, 1999, p.99). The spatial arrangement of a classroom affects student behavior. In many classrooms, the addition of furniture in a traditional designed classroom limits the mobility of students (Rydeen, 1999).

"The physical learning environment has two major elements, the architectural facility and the arranged environment" (Loughlin, 1982, p 1). "When behavior encouraged by the environment is expected and desired, teachers are more likely to respond in positive ways that support activities and learning" (Loughlin, 1982, p 50). "The amount of teacher time that is spent dispensing materials, presiding over routines, and managing child behavior can be minimized when the environment is arranged for that purpose" (Loughlin, 1982, p 7). If the arrangement does not match the activity, the segment will operate at less than optimal level (Ross, 1982). One "correct" room arrangement really doesn't exist. On average, teachers can rearrange classrooms in 1.4 minutes to achieve desired outcomes.

By arranging student seating in certain configurations, the teacher communicates how they wished the students to move about the room. The location of the teacher's desk and storage units limited the students' range of action within the classroom. The arrangement of the furnishings communicated to the students how the teacher regarded them and the teacher's role. The spatial arrangement was the physical expression of the relationship that the teacher expected to have with the students. If the teacher's desk was front and center and the student desks were in straight rows, the students knew what the relationship was and their actions in the relationship. Students who were seated at single desks expected they would work alone. Students seated at tables expected they would be working in collaboration with other students (Sargent, 1991, p 94).

"One basic design issue that teachers must address when arranging the classroom is whether the space should be organized in terms of personal territory or by functions" (Ross, 1982, p 10). If desks are in the center of the room, the majority of children's activities will be around their own desks (personal territory). The center of the room is a focus area regardless of its use for desks, as open space, a large group area or a small group area. Students will spend less time at their own desks is the desks are placed on the outside of the room (Lowe, 1990).
When desks are in rows..."much total space is used to separate desks and make room for movement" (Loughlin, 1982, p 37). With desks pushed together, side-by-side, with a narrow central aisle, attention is focused forward and talking is not permitted. No one needs to look at anything but the front of the room and no one needs to talk to anyone but the teacher (Manke, 1994). Rows produce individual on-task behavior (Wengel, 1992).

This typical classroom organization is not supportive of all activities. "Straight rows of desks all facing the same direction, for example, impede the development of strong, activity-oriented science programs" (Strange, 1981, p 46). "Students need opportunities to interact, share ideas, and draw upon each other's discoveries" (Strange, 1981, p 46). Using a table in the center of the room as a site of instruction and for the distribution of materials (function) draws attention to the fact that this activity is important.

To create additional space, teachers commonly arrange desks in groups of 3, 4, 6 or 8. This arrangement conserves space and increased communication among students. Keeping the desks together created broad walkways in the room. The increased space also made it easier for students to find a place to take a short break. Importantly, the extra space enabled students to work for longer periods of time. More child-child interactions take place in small groups. When the kids return to whole group, there is a higher level of contributing ideas, debating "and lower levels of responding to closed-end teacher questions, reiterating of ideas, and random conversations" (Shapiro, 1974, p 8). It is recommended that a circular seating arrangement be used during discussion (Wengel, 1992).

Where will you put your desk? Do you even want a teacher's desk in the room? It is not uncommon to find that teachers use their desk only when students are not in the room. In one classroom, it was found that the teacher had established 1/3 of the available floor space for her private use. Many teachers have moved their desks away from a front-and-center position in the room. In a decentralized position, teachers could privately discuss work with students (Kattef, 1974).

The organization of space is a classroom characteristic that can help or hinder student achievement. There is a need to find the space in classrooms to make good things happen. The fact remains that there is scant quantitative research into the impact of classroom organization on student achievement.

This is breakthrough research if it can be demonstrated that scores on the practical portion of the ESPET can be improved in a statistically significant way by changing the arrangement of the classroom furniture. Every grade-four teacher will benefit by knowing that changing the classroom furniture arrangement may result in improved student performance.
**BALL-AND-RAMP GAME**

**DIRECTIONS:** You and your partner will work together on this task. You may share your ideas by talking together quietly. Your answers may be the same as your partner’s answers, or they may be different. Each of you should record your results and answers in your own test booklet. Use the materials at this station to answer the following questions.

*** Do not move the blocks or the ruler. ***

- What is your partner’s first name? __________________________

- Be sure the cup is on the Starting Circle. The open end of the cup must be facing the end of the ruler. Take the golf ball out of the bag. Place the center of the golf ball on the 25-cm line near the top of the ruler, as shown in the diagram below. Release the golf ball. Do not push or force the ball down the ruler.

- Where did the dot on the cup stop? Check (✓) one.
  - Before the Finish Line
  - On the Finish Line
  - Past the Finish Line

Go on to page 3
1a. Put a check (✔) in the data table for 25 cm, Trial #1 to record where the dot stopped. Return the cup to the Starting Circle.

1b. Release the golf ball again from the 25-cm mark on the ruler. Put a check (✔) in the data table for 25 cm, Trial #2 to record where the dot stopped. Return the cup to the Starting Circle.

1c. Release the golf ball from different places on the ruler. Use the release points on the ruler given in the data table below. Record where the dot stopped for each trial that you and your partner perform. Return the cup to the Starting Circle at the end of each trial.

<table>
<thead>
<tr>
<th>Release Point on Ruler</th>
<th>Trial</th>
<th>Where the Dot Stopped (Check one)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before the Finish Line.</td>
</tr>
<tr>
<td>25 cm</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>25 cm</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>20 cm</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>20 cm</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>15 cm</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>15 cm</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>10 cm</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10 cm</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>5 cm</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5 cm</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Go on to page 4
2. Look back at your data table. At what point on the ruler should you release the golf ball to move the cup so that the dot stops on the Finish Line? Base your answer only on the data you collected.

____________________cm

3. Explain why in question #2 you chose that release point. Be specific.

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________
Raise your hand and get a Ping-Pong ball from the teacher. Take the Ping-Pong ball out of the bag. Release the Ping-Pong ball from the top of the ruler to see if it will work in the game. As the game is set up now, the Ping-Pong ball will not move the cup far enough.

4. Pretend that you could change one thing that might make the Ping-Pong ball move the dot on the cup to the Finish Line. What would that one change be? (The change may not be using a ball other than the Ping-Pong ball.)

5. Explain why you think your change in #4 would make the Ping-Pong ball move the dot on the cup to the Finish Line.

* When you have finished, give the Ping-Pong ball back to the teacher and put things back the way you found them.

STOP!
Appendix D

Reference to Syllabus and Learning Standards
<table>
<thead>
<tr>
<th>Station No.</th>
<th>Description</th>
<th>Purpose</th>
<th>Reference to NYS MST Standard 1, Scientific Inquiry (Elementary Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Liquids—Students use measuring equipment and their observation skills to determine the physical properties of objects, make inferences about discrepant events, and formulate new questions based on the data collected.</td>
<td>To assess students’ ability to use measuring equipment, make inferences about discrepant events, and formulate questions in the solution of a problem</td>
<td>measuring, inferring, Key Ideas: 1.1 and 1.3</td>
</tr>
<tr>
<td></td>
<td>Grouping Objects—Students sort a set of eight objects into appropriate groups and then create their own classification system by forming subgroups for the objects.</td>
<td>To assess students’ ability to sort objects into appropriate groups and create their own classification system to group objects</td>
<td>classifying, observing, manipulating materials, Key Ideas: 3.1 and 3.3</td>
</tr>
<tr>
<td>3</td>
<td>Ball-and-Ramp Game—Two students work together cooperatively at this task, which uses a ball-and-ramp “game.” The students gather data about problems associated with the development of the game. Students measure distance and make inferences and predictions based on the data they collect. Each student completes an answer sheet and makes predictions about how to modify the game.</td>
<td>To assess students’ ability to make observations, inferences, and predictions based on data collected in an experiment and to provide an opportunity for students to work together cooperatively in the solution of a problem</td>
<td>observing, recording data, Key Ideas: 1.2 and 1.3</td>
</tr>
<tr>
<td></td>
<td>Magnetic and Electrical Testing—Students use a magnet and electrical tester to collect data about a set of eight objects. They record their findings and use the data they collect to make inferences and generalizations about the magnetic and electrical properties of the set of objects.</td>
<td>To assess students’ ability to use a magnet and an electrical tester to collect data, make generalizations from their data, and make inferences based on their data</td>
<td>recording data, Key Ideas: 3.1 and 3.2</td>
</tr>
<tr>
<td>4</td>
<td>Unknown Object—Students are given an unknown object and are asked to describe it in a letter so that a scientist might be able to identify it. Students must use observation skills and nonstandard measurement to describe the object, communicate this information in writing, and ask additional questions of the scientist to further their investigation of the object.</td>
<td>To assess students’ observation and scientific communication skills and their ability to raise questions</td>
<td>observing, communicating, Key Ideas: 1.1 and 1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>communicating, using non-standard units of measure, 3.3</td>
</tr>
</tbody>
</table>
Appendix E

Item Difficulty
### Directions:
1. From Worksheet 2, Performance Test, Form Z record the local item difficulty for each item in the Local Difficulty column.
2. Put a circle around each local difficulty that is at or below the State Difficulty at Minimum Achievement Level.
3. Tally the circled items, based on reference to syllabus skill and reference to Standard 1, Scientific Inquiry, using Worksheets 4 and 5.

<table>
<thead>
<tr>
<th>Station</th>
<th>Item No.</th>
<th>Reference to Syllabus</th>
<th>Reference to Standard 1 - Scientific Inquiry</th>
<th>Local Item Difficulty</th>
<th>State Difficulty at Minimum Achievement Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1a</td>
<td>Measuring; Manipulating Materials</td>
<td>2.3</td>
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<td>1b</td>
<td>Measuring; Manipulating Materials</td>
<td>2.3</td>
<td>54</td>
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<td></td>
<td>1c</td>
<td>Measuring; Manipulating Materials</td>
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<td>4</td>
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<td>1d</td>
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<td>Inferring</td>
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<td></td>
<td>3</td>
<td>Questioning</td>
<td>1.1</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>Classifying; Observing; Manipulating Materials</td>
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<td></td>
<td>2</td>
<td>Classifying; Observing; Manipulating Materials</td>
<td>3.1, 3.3</td>
<td>88</td>
<td></td>
</tr>
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<td></td>
<td>3a</td>
<td>Classifying</td>
<td>3.3</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3b</td>
<td>Classifying</td>
<td>3.3</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Observing; Recording Data</td>
<td>2.3</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Interpreting Data; Inferring; Predicting</td>
<td>1.2, 1.3, 3.2</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Inferring</td>
<td>1.3</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Interpreting Data; Inferring</td>
<td>3.4</td>
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<td></td>
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<td>5</td>
<td>Interpreting Data; Inferring</td>
<td>1.3</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Recording Data; Manipulating Materials</td>
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<td>86</td>
<td></td>
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<tr>
<td></td>
<td>2</td>
<td>Generalizing; Inferring</td>
<td>3.2</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Recording Data; Manipulating Materials</td>
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<td>78</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Generalizing; Inferring</td>
<td>3.2</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Observing; Communicating; Using Nonstandard Units of Measure</td>
<td>1.3, 3.3</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Communicating; Questioning</td>
<td>1.1</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>
Appendix F

Superintendent's Letter of Permission
December 4, 2001

To Whom It May Concern;

Mr. Edward Duncanson is hereby granted permission to use school district data from the New York State Elementary Science Program Evaluation Test (ESPET) for his doctoral dissertation. He may also visit the classrooms of volunteer teachers for the purpose of mapping classroom arrangement and student movement.

Respectfully,

RoseMarie Stark
Acting Superintendent of Schools
Appendix G

School Report Card
Grade 4 Science
2000, 2001
Mountain View School District
Indian Lake Elementary School
Oak Ridge Elementary School
Grade 4 Science

Grade 4 Science Performance
(All Students: General Education and Special Education)

<table>
<thead>
<tr>
<th>Performance for This District</th>
<th>Counts of Students</th>
<th>School Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Tested</td>
<td>Multiple-Choice Test Component</td>
</tr>
<tr>
<td>IEP²</td>
<td>ELL²</td>
<td>Absent³</td>
</tr>
<tr>
<td>General Education</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special Education</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>All Students</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Grade 4 Science - Knowledge, Reasoning, and Problem Solving Standards

Multiple-Choice Test Component
This component is 45 multiple-choice questions based upon the New York State Elementary Science Syllabus and referenced to the New York State Learning Standards for Mathematics, Science and Technology (Elementary Level). Of the 45 questions, 17 reference Physical Setting; 17 reference Living Environment; 8 reference Scientific Inquiry; and 3 reference Mathematics.

State Designated Level (SDL)
Students who correctly answer fewer than 30 of the 45 questions of the Multiple-Choice Test Component must receive academic intervention services (AIS) in the following term of instruction.

Hands-On Performance Component
This component involves performance of hands-on tasks at 5 stations. The stations are named Liquids, Grouping Objects, Ball and Ramp Game, Magnetic and Electrical Testing, and Unknown Object. All tested students work at the Ball and Ramp Game. Approximately half the students work on Liquids and Grouping Objects and the other half work on Magnetic and Electrical Testing and Unknown Object. Schools use a statistically randomized procedure to assign students to these stations.

School Mean Scores
For the multiple-choice test component, this is the average number of correct answers for students tested. If all tested students answered all questions correctly, this score would be 45.

February 26, 2001

Mountain View School District

---

1. These students were exempt from this test because of disability as stated in their Individualized Educational Program (IEP).

2. These students were not required to take this test because they were English language learners (ELL) who performed below the 30th percentile on an appropriate English reading assessment and there was no test form available in their native language. Other ELL students must take this test, but may take an alternative language form if such is available.

3. These students were enrolled at the time of testing, but did not complete any part of this science assessment.

4. To protect student confidentiality, the pound character (#) appears when fewer than five students in a group were tested. If fewer than five were tested in one subgroup, then counts appear only in the "All Students" category.
# Grade 4 Science

## Grade 4 Science Performance

(All Students: General Education and Special Education)

<table>
<thead>
<tr>
<th>Performance at This School</th>
<th>Not Tested</th>
<th>Multiple-Choice Test Component</th>
<th>Performance Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IEP¹</td>
<td>ELL² Absent³</td>
<td></td>
</tr>
<tr>
<td>May 2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Education</td>
<td>0</td>
<td>0</td>
<td>107</td>
</tr>
<tr>
<td>Special Education</td>
<td>0</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>All Students</td>
<td>0</td>
<td>0</td>
<td>124</td>
</tr>
</tbody>
</table>

**Counts of Students**

Not Tested | Multiple-Choice Test Component | Performance Component |
---|---|---|
| | Tested | Above SDL | Tested | Multi-Choice | Performance |
| | | | | Scores | Scores |
| | | | | | | |
| | | | | | | |

**School Mean Scores**

- **Multiple-Choice Scores**
  - This component is 45 multiple-choice questions based upon the New York State Elementary Science Syllabus, and referenced to the New York State Learning Standards for Mathematics, Science and Technology (Elementary Level). Of the 45 questions, 17 reference Physical Setting; 17 reference Living Environment; 6 reference Scientific inquiry; and 3 reference Mathematics.

- **State Designated Level (SDL)**
  - Students who correctly answer fewer than 30 of the 45 questions of the Multiple-Choice Test Component must receive academic intervention services (AIS) in the following term of instruction.

- **Hands-On Performance Component**
  - This component involves performance of hands-on tasks at 5 stations. The stations are named Liquids, Grouping Objects, Ball and Ramp Game, Magnetic and Electrical Testing, and Unknown Object. All tested students work at the Ball and Ramp Game. Approximately half the students work on Liquids and Grouping Objects and the other half work on Magnetic and Electrical Testing and Unknown Object. Schools use a statistically randomized procedure to assign students to these stations.

- **School Mean Scores**
  - For the multiple-choice test component, this is the average number of correct answers for students tested. If all tested students answered all questions correctly, this score would be 45.

  For the performance component, the mean scores for the stations are added together to arrive at the school mean score. If all tested students received perfect scores, this score would be 45.

---

* Similar Schools are schools grouped by district and student demographic characteristics. More information is on the School Profile page of this report. Further explanation is available at [http://www.emsc.nysed.gov/report/2001/similar.html](http://www.emsc.nysed.gov/report/2001/similar.html).

1. These students were exempt from this test because of disability as stated in their individualized Educational Program (IEP).

2. These students were not required to take this test because they were English language learners (ELL) who perform below the 30th percentile on an appropriate English reading assessment and there was no test form available in their native language. Other ELL students must take this test, but may take an alternative language form if such is available.

3. These students were enrolled at the time of testing, but did not complete any part of this science assessment.

4. To protect student confidentiality, the pound character (#) appears when fewer than five students in a group were tested. If fewer than five were tested in one subgroup, then counts appear only in the "All Students" category.

---

February 26, 2001

Indian Lake Elementary School
## Grade 4 Science

### Grade 4 Science Performance
(All Students: General Education and Special Education)

<table>
<thead>
<tr>
<th>Performance at This School</th>
<th>Counts of Students</th>
<th>School Mean Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Tested</td>
<td>Multiple-Choice Test Component</td>
</tr>
<tr>
<td></td>
<td>IEP&lt;sup&gt;1&lt;/sup&gt;</td>
<td>ELL&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>General Education</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Special Education</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>All Students</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Grade 4 Science - Knowledge, Reasoning, and Problem-Solving Standards

**Multiple-Choice Test Component**
- This component is 45 multiple-choice questions based on the New York State Elementary Science Syllabus, and referenced to the New York State Learning Standards for Mathematics, Science and Technology (Elementary Level). Of the 45 questions, 17 reference Physical Setting; 12 reference Living Environment; 1 reference Scientific Inquiry; and 4 reference Mathematics.

**State Designated Level (SDL)**
- Students who correctly answer fewer than 30 of the 45 questions of the Multiple-Choice Test Component must receive academic intervention services (AIS) in the following term of instruction.

**Hands-On Performance Component**
- This component involves performance of hands-on tasks at 5 stations. The stations are named Liquids, Grouping Objects, Ball and Ramp Game, Magnetic and Electrical Testing, and Unknown Object. All tested students work on the Ball and Ramp Game. Approximately half the students work on Liquids and Grouping Objects and the other half work on Magnetic and Electrical Testing and Unknown Object. Schools use a statistically randomized procedure to assign students to these stations.

**School Mean Scores**
- For the multiple-choice test component, this is the average number of correct answers for students tested.
- For the performance component, the mean scores for the stations are added together to arrive at the school mean score. If all tested students answered all questions correctly, this score would be 45.

---

* Similar Schools are schools grouped by district and student demographic characteristics. More information is on the School Profile page of this report. Further explanation is available at [http://www.nysed.gov/report2001/simlar.html](http://www.nysed.gov/report2001/simlar.html).

1 These students were exempt from this test because of disability as stated in their Individualized Educational Program (IEP).

2 These students were not required to take this test because they were English language learners (ELL) who perform below the 30th percentile on an appropriate English reading assessment and there was no test form available in their native language. Other ELL students must take this test, but may take an alternative language form if such is available.

3 These students were enrolled at the time of testing, but did not complete any part of this science assessment.

# To protect student confidentiality, the pound character (#) appears when fewer than five students in a group were tested. If fewer than five were tested in one subgroup, then counts appear only in the “All Students” category.

---

February 26, 2001

Oak Ridge Elementary School

---

154
Grade 4 Science Performance
(All Students: General Education and Students with Disabilities)

<table>
<thead>
<tr>
<th>Performance of This District</th>
<th>Counts of Students</th>
<th>School Mean Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Net Tested</td>
<td>Multiple-Choice Test Component</td>
</tr>
<tr>
<td></td>
<td>AA¹</td>
<td>ELL²</td>
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<td>May 2000</td>
<td>General Education</td>
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<td>Students with Disabilities</td>
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<td></td>
<td>All Students</td>
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<tr>
<td>May 2001</td>
<td>General Education</td>
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<td></td>
<td>Students with Disabilities</td>
<td>0</td>
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<td></td>
<td>All Students</td>
<td>3</td>
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</table>

Grade 4 Science - Knowledge, Reasoning, and Problem-Solving Standards

- This component is 45 multiple-choice questions based upon the New York State Elementary Science Syllabus, and referenced to the New York State Learning Standards for Mathematics, Science, and Technology (Elementary Level). Of the 45 questions, 17 reference Physical Setting; 17 reference Living Environment; 6 reference Scientific Inquiry; and 3 reference Mathematics.

- Students who correctly answer fewer than 30 of the 45 questions of the Multiple-Choice Test Component must receive academic intervention services (AIS) in the following term of instruction.

- This component involves performance of hands-on tasks at 5 stations. The stations are named Liquids, Grouping Objects, Ball and Ramp Game, Magnetic and Electrical Testing, and Unknown Object. All tested students work at the Ball and Ramp Game. Approximately half the students work on Liquids and Grouping Objects and the other half work on Magnetic and Electrical Testing and Unknown Object. Schools use a statistically randomized procedure to assign students to these stations.

- For the multiple-choice test component, this is the average number of correct answers for students tested. If all tested students answered all questions correctly, this score would be 45.

- For the performance component, the mean score for the stations are added together to arrive at the school mean score. If all tested students received perfect scores, this score would be 48.

1 For 2001, these students were eligible for the Alternate Assessment (AA). For 2000 and 1999, these students were exempt from this test because of disability as stated in their Individualized Educational Program.

2 These students were not required to take this test because they were English language learners (ELL) who perform below the 30th percentile on an appropriate English reading assessment and there was no test form available in their native language. Other ELL students must take this test, but may take an alternative language form if such is available.

3 These students were enrolled at the time of testing but did not complete any part of this science assessment.

4 To protect student confidentiality, the pound character (#) appears when fewer than five students in a group were tested. If fewer than five were tested in one subgroup, then counts appear only in the "All Students" category.

March 11, 2002

Mountain View School District
## Elementary Level

### Science

#### Grade 4 Science Performance
(All Students: General Education and Students with Disabilities)

<table>
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<th>Year</th>
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<th>Absent</th>
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<th>Performance Component</th>
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</table>

#### Grade 4 Science - Knowledge, Reasoning, and Problem-Solving Standards

This component is 45 multiple-choice questions based upon the New York State Elementary Science Syllabus, and referenced to the New York State Learning Standards for Mathematics, Science and Technology (Elementary Level). Of the 45 questions, 17 reference Physical Setting; 17 reference Living Environment; 8 reference Scientific Inquiry; and 3 reference Mathematics.

State Designated Level (SDL): Students who correctly answer fewer than 30 of the 45 questions of the Multiple-Choice Test Component must receive academic intervention services (AIS) in the following term of instruction.

Performance Component: This component involves performance of hands-on tasks at 5 stations. The stations are named Liquids, Grouping Objects, Ball and Ramp Game, Magnets and Electrical Testing, and Unknown Object. All tested students work at the Ball and Ramp Game. Approximately half the students work on Liquids and Grouping Objects and the other half work on Magnets and Electrical Testing and Unknown Object. Schools use a statistically randomized procedure to assign students to these stations.

School Mean Scores: For the multiple-choice test component, this is the average number of correct answers for students tested. If all tested students answered all questions correctly, this score would be 45. For the performance component, the mean scores for the stations are added together to arrive at the school mean score. If all tested students received perfect scores, this score would be 45.

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1 For 2001, these students were eligible for the Alternate Assessment (AA). For 2000 and 1999, there were some cases where students were exempt from the test due to disabilities as stated in their Individualized Educational Program.

2 These students were not required to take this test because they were English language learners (ELL) who perform below the 30th percentile on an appropriate English reading assessment and there was no test form available in their native language.

3 Other ELL students must take this test, but may take an alternative language form if such is available.

4 These students were enrolled at the time of testing but did not complete any part of this science assessment.

5 To protect student confidentiality, the pound character (#) appears when fewer than five students in a group were tested. If fewer than five were tested in one subgroup, then counts appear only in the "All Students" category.

March 11, 2002

Indian Lake Elementary School

156
Elementary Level
Science

Grade 4 Science Performance
(All Students: General Education and Students with Disabilities)

<table>
<thead>
<tr>
<th></th>
<th>1998-00</th>
<th>2000-01</th>
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<td>This School</td>
<td></td>
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<tr>
<td>Percent Above SDL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple-Choice Mean Score</td>
<td></td>
<td></td>
</tr>
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<tr>
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<td></td>
</tr>
<tr>
<td>Multiple-Choice Mean Score</td>
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Performance at This School

Counts of Students

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<th>Absent^3</th>
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<td>All Students</td>
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<td>Tested</td>
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</table>

School Mean Scores

Grades 4 Science - Knowledge, Reasoning, and Problem-Solving Standards

Multiple-Choice Test Component

This component is 45 multiple-choice questions based upon the New York State Elementary Science Syllabus, and referenced to the New York State Learning Standards for Mathematics, Science, and Technology (Elementary Level). Of the 45 questions, 17 reference Physical Setting; 17 reference Living Environment; 8 reference Scientific Inquiry; and 3 reference Mathematics.

State Designated Level (SDL)

Students who correctly answer fewer than 30 of the 45 questions of the Multiple-Choice Test Component must receive academic intervention services (AIS) in the following term of instruction.

Performance Component

This component involves performance of hands-on tasks at 5 stations. The stations are named Liquids, Grouping Objects, Bell and Ramp Game, Magnets and Electrical Testing, and Unknown Object. All tested students work at the Bell and Ramp Game. Approximately half the students work on Liquids and Grouping Objects and the other half work on Magnets and Electrical Testing and Unknown Object. Schools use a statistically randomized procedure to assign students to these stations.

School Mean Scores

For the multiple-choice test component, this is the average number of correct answers for students tested. If all tested students answered all questions correctly, this score would be 45.

For the performance component, the mean scores for the stations are added together to arrive at the school mean score. If all tested students received perfect scores, this score would be 45.

* Similar Schools are schools grouped by district and student demographic characteristics. More information is on the School Profile page of this report. Further explanation is available at http://www.emis.nysed.gov/psc/2002/similar.html.

1 For 2001, these students were eligible for the Alternate Assessment (AA). For 2000 and 1999, these students were exempt from this test because of disability as stated in their Individualized Educational Program.

2 These students were not required to take this test because they were English language learners (ELL) who perform below the 30th percentile on an appropriate English reading assessment and there was no test form available in their native language. Other ELL students must take this test, but may take an alternative language form if such is available.

3 These students were enrolled at the time of testing but did not complete any part of this science assessment.

To protect student confidentiality, the pound character (#) appears when fewer than five students in a group were tested. If fewer than five were tested in one subgroup, then counts appear only in the "All Students" category.

March 11, 2002

Oak Ridge Elementary School

157
Appendix H

Performance Test, Form Z Worksheets
Directions:
1. Score each student test booklet.
2. From each test booklet, record each item score in the appropriate column by station.
3. Total each vertical item column to determine the total class score for each item.
4. Enter the total number of students who responded at each station in the Total Students row.

NOTE: Because there are two different test booklets, the number of students responding to the items in stations 1, 2, 4, and 5 will be approximately one half of the class. All students will respond to station 3.
5. Transfer the number of students at each station and each total item score to Performance Test, Form Z Worksheet 2.

<table>
<thead>
<tr>
<th>Items</th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
<th>Station 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1a 1b 1c 1d 2 3</td>
<td>1 2 3a 3b</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4</td>
<td>1 2</td>
</tr>
<tr>
<td>Maximum Value</td>
<td>2 2 2 2 2</td>
<td>2 2 2 2</td>
<td>2 1 2 2 2</td>
<td>3 2 3 2</td>
<td>6 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STUDENT</th>
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<th></th>
<th></th>
<th></th>
<th></th>
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<td>30</td>
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</tr>
</tbody>
</table>

Total Score
Total Students
Building or District Worksheet

Item Difficulty

Directions:
1. From Worksheet 1, Performance Test, Form Z for each class, record the total number of students that responded to each station and each total item score.
2. Total each vertical column to determine the total number of students for each station and the total score for each item across all classes. This information should appear in the shaded row.
3. Determine the mean score for each item (round to the nearest .01):
   \[
   \text{Mean Score for Each Item} = \frac{\text{Total Score for Each Item}}{\text{Total Number of Students for That Station}}
   \]
4. Convert the mean item score for each item to an item difficulty (round to the nearest whole number):
   \[
   \text{Local Item Difficulty} = \left\lfloor \frac{\text{Mean Item Score} \times 100}{\text{Maximum Item Value}} \right\rfloor
   \]
5. Transfer each Local Item Difficulty to Performance Test, Form Z, Worksheet 3.

<table>
<thead>
<tr>
<th>Class</th>
<th>Number of Students at Each Station</th>
<th>Station 1</th>
<th>Station 2</th>
<th>Station 3</th>
<th>Station 4</th>
<th>Station 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 a</td>
<td>1 b</td>
<td>1 c</td>
<td>1 d</td>
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</table>
ITEMS GROUPED BY NYS SYLLABUS SKILL

Directions:
1. From Performance Test Worksheet 3, tally the items that fall into each of the skill areas below. Count the tally marks and note this number in the third column.
2. Determine the % of items in this skill area below the State Difficulty at Minimum Achievement Level:
   \[
   \left( \frac{\text{Number of Items below the State Difficulty}}{\text{Number of Items on Performance Test}} \right) \times 100
   \]
3. Put a circle around each percentage that is greater than 50%.
4. Note the circled skill area(s) on the Program Weaknesses Worksheet.
5. Mark an S if the skill area is less than 50%.

NOTE: Some areas contain too few items to make a meaningful comparison.

<table>
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<tr>
<th>NYS Syllabus Skill</th>
<th>Item Numbers</th>
<th>Number of Items on Performance Test that Test this Skill</th>
<th>Number of Items on Performance Test Worksheet 3 that were below the State Difficulty at Minimum Achievement Level for this Skill</th>
<th>% of items in this skill area that were below the State Difficulty at Minimum Achievement Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classifying</td>
<td>Station 2: 1, 2, 3a, 3b</td>
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<tr>
<td>Communicating</td>
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<td>Generalizing</td>
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<td>Station 3: 2, 3, 4</td>
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<tr>
<td></td>
<td>Station 4: 2, 4</td>
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</tr>
<tr>
<td>Interpreting data</td>
<td>Station 3: 2, 4, 5</td>
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<tr>
<td>Manipulating materials</td>
<td>Station 1: 1a, 1b, 1c, 1d</td>
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</tr>
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<td></td>
<td>Station 2: 1, 2</td>
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<td>Station 4: 1, 3</td>
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<td>Observeing</td>
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</tr>
<tr>
<td></td>
<td>Station 3: 1</td>
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<tr>
<td></td>
<td>Station 5: 1</td>
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</tr>
<tr>
<td>Predicting</td>
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<td>too few items</td>
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<td>Questioning</td>
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<tr>
<td></td>
<td>Station 5: 2</td>
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</tr>
<tr>
<td>Recording data</td>
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<td></td>
<td>Station 4: 1, 3</td>
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<td>Using nonstandard units of measure</td>
<td>Station 5: 1, 2</td>
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</table>

161
ITEMS GROUPED BY KEY IDEA IN STANDARD 1. SCIENTIFIC INQUIRY

Directions:
1. From Performance Test Worksheet 3, tally the items that fall into each of the Key Ideas below. Count the tally marks and note this number in the third column.
2. Determine the % of items in this Key Idea below the State Difficulty at Minimum Achievement Level:
   \[
   \left(\frac{\text{Number of Items below the State Difficulty}}{\text{Number of Items on Performance Test}}\right) \times 100
   \]
3. Put a circle around each percentage that is greater than 50%.
4. Note the circled Key Idea(s) on the Program Weaknesses Worksheet.
5. Mark an S if the key idea is less than 50%.

NOTE: Some areas contain too few items to make a meaningful comparison.

<table>
<thead>
<tr>
<th>NYS Learning Standard 1 Scientific Inquiry Key Ideas</th>
<th>Item Numbers</th>
<th>Number of Items on Performance Test that Test this Key Idea</th>
<th>Number of Items on Performance Test Worksheet 3 that were below the State Difficulty at Minimum Achievement Level for this Key Idea</th>
<th>% of items related to this Key Idea that were below the State Difficulty at Minimum Achievement Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Station 1: 3, Station 5: 2</td>
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<td>too few items</td>
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<td>1.2</td>
<td>Station 3: 2</td>
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<td>too few items</td>
<td>too few items</td>
</tr>
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<td>1.3</td>
<td>Station 1: 2, Station 3: 2, 3, 5, Station 5: 1</td>
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<td></td>
</tr>
<tr>
<td>2.1</td>
<td>none</td>
<td>0</td>
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<td>too few items</td>
</tr>
<tr>
<td>2.2</td>
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<td>0</td>
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<td>too few items</td>
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<td>2.3</td>
<td>Station 1: 1a, 1b, 1c, 1d, Station 3: 1</td>
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<td></td>
<td></td>
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<td>3.1</td>
<td>Station 2: 2, Station 4: 1, 3</td>
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<td>3.2</td>
<td>Station 3: 3, Station 4: 2, 4</td>
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<tr>
<td>3.3</td>
<td>Station 2: 1, 2, 3a, 3b, Station 5: 1</td>
<td>5</td>
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<td>3.4</td>
<td>Station 3: 4</td>
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<td>too few items</td>
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</tbody>
</table>
Appendix I

Classroom Maps
Indian Lake Elementary School

Room #1 - Furniture

A. 2-Door Metal Cabinet
B. Open Shelves
C. Book Shelves
D. Cart on Wheels
E. A-Frame Plant Stand
F. 5-Drawer Art Project Storage Table
G. Storage Rack with Wheels
H. Table
I. File Cabinet
J. Computer Table
K. Double Sink with Overhead Storage
L. Student Coat Rack with Overhead Storage
M. 2-Door Cabinet
N. Rug
O. Overstuffed Chair
P. Table
Q. Waste Paper Can
R. Table
S. Table – Rounded on two corners
T. Hanging Chart
U. Teacher Desk
V. Storage Drawers
W. Stool
SD. Student Desk
Indian Lake Elementary School

Room #2 - Furniture

A. 2-Door Metal Cabinet
B. Open Face Cabinet
C. 2-Door Wood Cabinet
D. Student Coat Rack with Overhead Storage
E. Table
F. Teacher Desk
G. Waste Paper Can
H. 2-Shelf Rolling Metal Bookcase
I. Table
J. Shelves
K. Chart Stand
L. File Cabinet
M. Tiered Book Rack
N. Table
O. Overhead Projector Cart
P. Rug
Q. Stool
R. Table
SD. Student Desk
INDIAN LAKE ELEMENTARY SCHOOL
ROOM # 3

CB = CHALKBOARD

CB = CHALKBOARD
Indian Lake Elementary School

Room #3 - Furniture

A. Map Storage Table
B. Bin
C. Double Sink with Overhead Storage
D. Student Coat Rack with Overhead Storage
E. Closet
F. Table on wheels
G. Computer Table
H. File Cabinet
I. Teacher Aide Desk
J. Bookshelf
K. Rug
L. Magazine Rack
M. Shelves
N. Cart
O. Teacher Desk
P. Overhead Cart
Q. Table
S. Waste Paper Can
SD. Student Desk
Oak Ridge Elementary School

Room #4 – Furniture

A. Bathrooms
B. Sink and Counter with overhead storage
C. Cabinet
D. Computer Table
E. Computer Table
F. Book Case
G. Table
H. Fan
I. File Cabinet
J. Refrigerator
K. Computer Table, adjustable
L. Mailboxes
M. Shelves
N. Cubby and seat, coat rack
O. Closet
P. Low Shelves
Q. File
R. Low Shelves
S. Shaped Table
T. Teacher Desk
U. Cabinet
V. Overhead Projector Cart
W. Book Rack
X. Book Shelf
Y. Stool
Z. Waste Paper Can
SD. Student Desk
Oak Ridge Elementary School

Room #5 – Furniture

A. Sink and Counter with Overhead Storage
B. Cabinet
C. Rolling Shelves
D. Overhead Cart
E. Teachers Desk
F. Waste Paper Can
G. File Cabinet
H. Table
I. Computer Table
J. Moveable Bulletin Board
K. Table
L. Bin
M. Cubby and seat, coat rack
SD. Student Desks
Appendix J

Spatial Utilization Form for Each Classroom
Classroom Spatial Utilization and Migration Observation Form

School: Indian Lake Elem. Room # 1 Date: ________ Time: ________

Number of Teachers ______ Number of Students ______

Physical Characteristics

Classroom

Traditional X Area 847 sq. ft.
Modified ______ Ceiling Height 9'2"
Open ______ Volume 7,767 cu.ft.
Appearance [1(poor) - 5(good)] 3

Windows

Number 6 Operable 6 Inoperable
Distracting Glare no Size 44" x 70" Location (N,S,E,W) NNE

Lighting

Bright ______ Drop ______ Full-Spec ______
Normal X Indirect ______ Cool/White Fluor X
dim ______ Recessed ______ Diffused X

Floor Covering

Carpet ______ Color Green
Concrete ______
Tile X
gwood ______
Other ______

Wall Covering

Brick ______ Plaster X Wall Board ______ Color Cream
Tile ______ Cement Block ______
Teacher Personal Storage

Closet  X  Shelves  X  File  X  Other  

Student Personal Storage

Closet  X  Shelves  _____  Bins  _____
Desks  X  Tables  _____  Other  _____

Material Storage

Closet  X  Shelves  X  Bins  X  Other  _____

Heating/Cooling

Type  
Ceiling unit  _____  Radiator  X  Window unit  _____  Floor unit  _____
Comfort Zone [1(poor) – 5(good)]  4  

Furniture

Shelving/Storage  Built-in  X  Moveable  X  

Student Work Areas

Personal desks  X  Small tables  X  Large Tables  _____  Study Carrels  _____

Teacher Work Areas

Teacher Desk  X  Table  _____  Other  _____

Condition  [1(poor) – 5(good)]  3  

Spatial Characteristics

Teacher Area  Square Ft.  79  %  9
Furniture  Square Ft.  225  %  27
Open Space  Square Ft.  543  %  64
Classroom Spatial Utilization and Migration Observation Form

School: Indian Lake Elem. Room # 2 Date: ________ Time: ________

Number of Teachers ______ Number of Students ______

Physical Characteristics

Classroom

Traditional X Area 847 sq. ft.
Modified ________ Ceiling Height 9'2"
Open ________ Volume 7,767 cu. ft.

Appearance [1(poor) – 5(good)] 3

Windows

Number 6 Operable 6 Inoperable ________
Distracting Glare no Size 44" x 70" Location (N,S,E,W) SSW

Lighting

Bright ________ Drop ________ Full-Spec ________
Normal X ________ Indirect ________ Cool/White Fluor X ________
Dim ________ Recessed ________ Diffused X ________

Floor Covering

Carpet ________ Color Rust ________
Concrete ________
Tile X ________
Wood ________
Other ________

Wall Covering

Brick ________ Plaster X ________ Wall Board ________ Color Light Blue ________
Tile ________ Cement Block ________
Teacher Personal Storage

Closet _X_  Shelves _X_  File _X_  Other _____

Student Personal Storage

Closet _X_  Shelves _____  Bins _____
Desks _X_  Tables _____  Other _____

Material Storage

Closet _X_  Shelves _X_  Bins _X_  Other _____

Heating/Cooling

Type ____________________________
Ceiling unit ______  Radiator _X_  Window unit _____  Floor unit ______
Comfort Zone [1(poor) – 5 (good)] 4

Furniture

Shelving/Storage  Built-in _X_  Moveable _X_

Student Work Areas

Personal desks _X_  Small tables _X_  Large Tables _X_  Study Carrels ______

Teacher Work Areas

Teacher Desk _X_  Table _X_  Other _____

Condition  [1(poor) – 5(good)] 3

Spatial Characteristics

Teacher Area  Square Ft. 75  % 7
Furniture  Square Ft. 262  % 31
Open Space  Square Ft. 510  % 60
Classroom Spatial Utilization and Migration Observation Form

School: Indian Lake Elem. Room # 3 Date: ________ Time: ________

Number of Teachers _______ Number of Students _______

Physical Characteristics

Classroom

Traditional X Area 847 sq. ft.
Modified _______ Ceiling Height 9'2"
Open _______ Volume 7,767 cu. ft.
Appearance [1(poor) – 5(good)] 3

Windows

Number 6 Operable 6 Inoperable _______
Distracting Glare no Size 44" x 70" Location (N,S,E,W) NNE

Lighting

Bright _______ Drop _______ Full-Spec _______
Normal X Indirect _______ Cool/White Fluor X_____
Dim _______ Recessed _______ Diffused X_____ 

Floor Covering

Carpet _______ Color Mud Brown _______
Concrete _______ 
Tile X_____
Wood _______
Other _______

Wall Covering

Brick _______ Plaster X Wall Board _______ Color Cream_____
Tile _______ Cement Block _______
### Teacher Personal Storage

- Closet: X
- Shelves: X
- File: X
- Other: 

### Student Personal Storage

- Closet: X
- Shelves: 
- Bins: 
- Tables: 
- Other: 

### Material Storage

- Closet: X
- Shelves: X
- Bins: X
- Other: 

### Heating/Cooling

- Type: 
- Ceiling unit: 
- Radiator: X
- Window unit: 
- Floor unit: 
- Comfort Zone: [1(poor) – 5(good)] 3

### Furniture

- Shelving/Storage: 
- Built-in: X
- Moveable: X

### Student Work Areas

- Personal desks: X
- Small tables: 
- Large Tables: X
- Study Carrels: 

### Teacher Work Areas

- Teacher Desk: X
- Table: X
- Other: 

### Condition

- [1(poor) – 5(good)] 3

### Spatial Characteristics

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Classroom Spatial Utilization and Migration Observation Form

School: Oak Ridge Elem  Room #: 4  Date:  Time:  
Number of Teachers  Number of Students  

Physical Characteristics  

Classroom  
Traditional  X  Area  777 sq. ft.  
Modified  Ceiling Height  9 ft.  
Open  Volume  6,993 cu. ft.  
Appearance [1(poor) – 5(good)]  4  

Windows  
Number  5  Operable  5  Inoperable  
Distracting Glare  yes  Size  33” x 64”  Location (N,S,E,W)  SSE  

Lighting  
Bright  Drop  Full-Spec  
Normal  X  Indirect  Cool/White Fluor  X  
Dim  Recessed  X  Diffused  X  

Floor Covering  
Carpet  X  Color  Dark Blue  
Concrete  
Tile  
Wood  
Other  

Wall Covering  
Brick  Plaster  Wall Board  X  Color  Off White, Dark Blue  
Tile  Cement Block  X  

181
Teacher Personal Storage

Closet _X_  Shelves _X_  File _X_  Cabinet _X_

Student Personal Storage

Closet _  Shelves _X_  Cubby _X_
Desks _X_  Tables _X_  Other _____

Material Storage

Closet _  Shelves _X_  Bins _  Other _____

Heating/Cooling

Type _HVAC_  Ceiling unit _  Radiator _  Window unit _  Floor unit _X_
Comfort Zone [1(poor) -- 5 (good)] _____

Furniture

Shelving/Storage _  Built-in _X_  Moveable _X_

Student Work Areas

Personal desks _X_  Small tables _X_  Large Tables _X_  Study Carrels _____

Teacher Work Areas

Teacher Desk _X_  Table _  Other _____

Condition [1(poor) -- 5(good)] 5

Spatial Characteristics

Teacher Area  Square Ft. 57  % 7
Furniture  Square Ft. 226  % 29
Open Space  Square Ft. 494  % 64
Classroom Spatial Utilization and Migration Observation Form

School: Oak Ridge Elem Room # 5 Date: _______ Time: _______

Number of Teachers_____ Number of Students_____ 

Physical Characteristics

Classroom

Traditional _X_ Area_799 sq. ft._
Modified____ Ceiling Height_9 ft._
Open____ Volume_7,191 cu. ft._
Appearance [1(poor) – 5(good)] ___4___ 

Windows

Number __5__ Operable __5__ Inoperable _____
Distracting Glare __no__ Size_33” x 64” Location (N,S,E,W) ____NNW____

Lighting

Bright____ Drop______ Full-Spec____
Normal _X_ Indirect______ Cool/White Fluor __X____
Dim____ Recessed __X__ Diffused _X_ 

Floor Covering

Carpet __X__ Color __Dark Green__
Concrete____
Tile____
Wood____
Other______

Wall Covering

Brick____ Plaster____ Wall Board __X__ Color __Off White, Dark Teal__
Tile____ Cement Block __X__ 

183
Teacher Personal Storage

- Closet
- Shelves X
- File X
- Cabinet X

Student Personal Storage

- Closet
- Shelves X
- Cubby X
- Desks X
- Tables X
- Other

Material Storage

- Closet
- Shelves X
- Bins
- Other

Heating/Cooling

- Type HVAC
- Ceiling unit
- Radiator
- Window unit
- Floor unit X
- Comfort Zone [1 (poor) – 5 (good)]

Furniture

- Shelving/Storage
  - Built-in X
  - Moveable X

Student Work Areas

- Personal desks X
- Small tables
- Large Tables X
- Study Carrels

Teacher Work Areas

- Teacher Desk X
- Table
- Other

Condition [1 (poor) – 5 (good)] 5

Spatial Characteristics

- Teacher Area
  - Square Ft. 50
  - % 6
- Furniture
  - Square Ft. 185
  - % 23
- Open Space
  - Square Ft. 564
  - % 71
Appendix K

Graphs of Migration Patterns for Each Classroom
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**Classroom Utilization and Migration Form**

**School**: Indian Lake

**Room #**: 1

**Date**: 5-7-02

---

**Key**

- A – Student Desk Area
- B – Teacher’s Desk Area
- C – Materials Area
- D – Alternative Functional Area
- T – Time Intervals
**Classroom Utilization and Migration Form**

School: *Indian Lake*

Room #: 2

Date: 4-16-02

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% of Classroom Area Use Over Time

A - Student Desk Area
B - Teacher's Desk Area
C - Materials Area
D - Alternative Functional Area

T - Time Intervals
Classroom Utilization and Migration Form

School  Indian Lake
Room #  3
Date  5-1-02

Key
A – Student Desk Area
B – Teacher's Desk Area
C – Materials Area
D – Alternative Functional Area
T – Time Intervals
### Classroom Utilization and Migration Form

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#### Key

- A – Student Desk Area
- B – Teacher’s Desk Area
- C – Materials Area
- D – Alternative Functional Area
- T – Time Intervals
### Classroom Utilization and Migration Form

**School**: Oak Ridge  
**Room #**: 5  
**Date**: 4-24-02

#### Key
- A - Student Desk Area  
- B - Teacher's Desk Area  
- C - Materials Area  
- D - Alternative Functional Area  
- T - Time Intervals

| T | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| % of Classroom Area Use Over Time |  
| A |  
| B |  
| C |  
| D |  

Diagram: Grid layout with letters and numbers indicating areas of use.
Appendix L

Migration Maps for Each Classroom
CB = CHALKBOARD
Appendix M

Grade-4 Science PET: Part Scores from Form Z, 2000-2001
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Note: *Maximum score = 2. **Maximum score = 12
### Grade-4 Science PET: Part Scores from Form Z, 2000 - 2001

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Note: *Maximum score = 2. *Maximum score = 8.
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Note: <sup>a</sup>Maximum score = 2. <sup>b</sup>Maximum score = 1. <sup>d</sup>Maximum score = 9.
# Grade-4 Science PET: Part Scores from Form Z, 2000 - 2001

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Note: <sup>e</sup>Maximum score = 2. <sup>a</sup>Maximum score = 3. <sup>f</sup>Maximum score = 10. <sup>g</sup>Maximum score = 6. <sup>h</sup>Maximum score = 4.
Appendix N

SPSS T-Test Output
## Descriptives

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## T-Test

### Group Statistics

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Appendix O

SPSS Regression Output
Regression

Variables Entered/Removed

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a. All requested variables entered.
b. Dependent Variable: sq ft/pupil

Model Summary

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a. Predictors: (Constant), ALFGKI

ANOVA<sup>b</sup>

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a. Predictors: (Constant), ALFGKI
b. Dependent Variable: sq ft/pupil

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a. Dependent Variable: sq ft/pupil