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ABSTRACT

This report describes a program designed to increase students' knowledge in the science content area utilizing reading comprehension strategies. The targeted population consisted of grade 6 middle school students in a growing urban community in eastern Iowa. The students demonstrated poor comprehension of their science textbook. Data also revealed that these students produced work of substandard quality and lacked motivation. A review of solution strategies suggested by cited authors, combined with an analysis of the problem setting, resulted in the selection of one major category of intervention designed to increase class participation, the base knowledge of science, and motivation. The study yielded few perceptible increases in student achievement, student participation, or application of reading skills to science activities for students in the experimental groups as compared to students in the control group. Students in the experimental group stated that they felt that studying science in both reading and science class was helpful. (Contains 52 references, 10 appendices, and numerous tables and charts.) (DDR)

INCREASING STUDENT SCIENCE ACHIEVEMENT THROUGH APPLICATION OF STRATEGIES LEARNED IN READING CLASS

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ABSTRACT

This report describes a program designed to increase students knowledge in the science content area utilizing reading comprehension strategies. The targeted population consisted of sixth grade middle school students in a growing urban community located in eastern Iowa. That students demonstrated poor comprehension of the science text, a lack of application of reading skills to the science curriculum, work of substandard quality, and a lack of motivation were documented through data revealing the number of students underachieving in science.

Analysis of probable causes was evidenced by teachers' observations of students coming to class unprepared, demonstrating poor participation in classroom discussions, scoring poorly on tests and quizzes, and displaying a lack of motivation. Teachers reported that students did not apply reading strategies to science lessons. Review of science curricular content and reading skills taught revealed a lack of transfer of these skills to science curriculum.

A review of solution strategies suggested by cited authors, combined with an analysis of the problem setting, resulted in the selection of one major category of intervention. Instruction of reading skills to students in reading class will result in the following outcomes for those same students in science class: an increase in class participation, more frequent application of reading strategies to science curriculum, an increase in the base knowledge of science, and an increase in motivation.

The study yielded few perceptible increases in student achievement, student participation, or application of reading skills to science activities for students in the experimental groups as compared to students in the control group. However, students in the experimental groups stated they felt that studying science in both reading and science classes was helpful.

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CHAPTER 1

PROBLEM STATEMENT AND CONTEXT

General Statement of the Problem

In a Midwest metropolitan area school a number of sixth grade students are underachieving in science. Teachers observe that students come to class unprepared, demonstrate poor participation in class discussions, produce work of substandard quality, and display a lack of motivation towards academia.

Data will be collected in the form of pretests/posttests, questionnaires, student surveys, observational checklists, student reflections, and scores from quizzes and daily assignments. This information will be utilized to measure students' degree of comprehension of the science text, degree of application of specific reading strategies to activities within the science curriculum, individual academic accountability, and student motivation in science class.

Local Setting

The targeted middle school, located in the Quad City area, was constructed in 1954. This modern, one-story building lies on 34 acres of land in an urban middle-class neighborhood. There are 49 classrooms, 3 teacher lounges, 2 gymnasiums, and 1 cafeteria which also serves as a multi-purpose room.

In the 1996-1997 school year, 733 sixth, seventh, and eighth grade students attended the targeted school. Based on the January 1997 school district's enrollment report, the school's student population is diversified as follows: 70.4% Caucasian; 10.8% African-American; 10% Asian; 7% Hispanic; 1% Bi-racial; and 0.3% Native-American. Of the total student body, 39.7% participate in the free or reduced lunch program. Student attendance is stable; 95% of the student population is present daily. Although many students walk to school or are driven in private vehicles, 35.8% use school busing.

The targeted intermediate school is unique to the district. Offered to students is a bilingual language arts class in grade 6 and an English-As-a-Second Language (ESL) course of study in grades 6, 7, and 8. In addition to ESL and bilingual language arts, programs available to students include Accelerated Gifted and Talented Education (AGATE), Learning Disabled (LD) resource, Mentally Disabled (MD) self-contained, adaptive physical education, speech pathology, and counseling services.

Among the 60 certified staff members at the targeted school, teaching degrees are diversified as follows: 58% of certified staff possess a bachelor's degree, 40% have earned a master's degree, and 2% completed a doctorate. Teaching experience among staff members varies as follows: 19% have 0-5 years of teaching experience, 19% have taught 6-10 years, and 61% of the staff have worked in the teaching profession for more than 10 years.

In addition to certified staff members at the targeted intermediate school, classified personnel are employed as well. Staff members' jobs are classified as follows: 14 paraprofessionals, 6 custodians, 4 secretaries, and 1 nurse. On loan to the school building from the area education association are 2 educational psychologists and 1 social worker.

Community Setting

Davenport is located in eastern Iowa on the Mississippi River, 165 miles west of Chicago, Illinois. The community is served by Interstate 80, Interstate 74, and Interstate 88, as well as several major state highways. The area encompasses approximately 12 communities. Davenport is the largest of four adjoining cities that make up the Quad Cities; the other three cities are Moline, Rock Island, and Bettendorf. Nearly 400,000 people populate the Quad Cities. The Quad City Airport provides residents and visitors with national and international air transportation.

Historically, Davenport housed an Indian settlement and trading center prior to the time when French explorers investigated the shores of the Mississippi River. An early military post was later used as a prisoner-of-war camp for captured Confederate soldiers and eventually grew into what is currently the oldest and largest manufacturing arsenal in the nation.

The Quad Cities is an enterprising retail and commercial center. Its early lumber industry has evolved into manufacturing and assembly operations. Entrepreneurs of steamboat companies and railway companies, drawn by access to the Mississippi River, helped to forge the area's position as one of the most vital transportation hubs in the United States.

Several large corporations and factories are located in the Quad Cities. These companies include Aluminum Company of America (ALCOA), The John Deere Company, Case Corporation, Oscar Mayer Foods Corporation, and Ralston Purina Company.

More than 300 social service organizations offer assistance to people in the Quad Cities. Among these organizations are United Way of the Quad Cities, The Salvation Army, Catholic Social Services, Center for Aging Services Inc. (CASI), Handicapped Development Center, and the John Lewis Coffee Shop for the Homeless.

There are 365 religious congregations in the Quad Cities. Congregations are comprised of the following populations: 84% Protestant, 9% Catholic, 0.5% Jewish, and 5% other faiths or nondenominational.

Residents and visitors enjoy a wide variety of cultural and recreational attractions. Among entertainments offered are spectator sports, such as those provided by the Quad City Mallard hockey team and the River Bandits baseball team; concerts and family shows at The Mark of the Quad Cities; performing arts at Circa '21 Dinner Playhouse and the Playcrafters Barn Theatre; and performances of the Quad City Symphony Orchestra at the River Center/Adler Theatre. Hiking and bicycling along the Ben Butterworth Parkway and Duck Creek Park bike path, and river tours, such as the Mississippi Riverboat Gambling and Sightseeing Excursions and Twilight cruise are popular forms of diversion.

The Quad City area draws from a work force of nearly 200,000 people. The unemployment rate is consistently near 4%. The majority of the employed are skilled laborers, while service jobs have been steadily on the rise. Median household income in Davenport is $27,941.

Housing in the Quad Cities is affordable. According to a 1995 housing survey administered by the Davenport National Home Builders Association, housing affordability in Davenport ranks 21st among 188 similar metropolitan areas. The average sale price of a home or condominium is $77,100.

The violent crime rate in the Quad City area is substantially higher than other locations in the Midwest, South, West, and Northeast. The rate of property crimes in cities of comparable size located in the South and West were higher than that of the Quad Cities; property crimes in cities of comparable size located in the Midwest and Northeast were lower than that of the Quad Cities.

The school district has a culturally diverse student population. A 1997 district ethnic enrollment report sites the following ethnic student composition: 73.5% Euro-American, 15.5% African-American, 5.5% Hispanic, 2.4% Asian, 1.9% Bi-racial, and 1.2% Native-American.

The school district promotes many exemplary programs. Noted curricula include Schools of Excellence (SOE), Drug and Alcohol Resistance Education (D.A.R.E.), At-Risk Head Start, Prep-for-School, Special Education, Preschool, Solutions, Youth Alternative, Teen Academic and Parenting, Bilingual Education, and English-As-a-Second Language.

The area is served by several institutes of higher education. The American Institute of Commerce, Scott Community College, Hamilton Technical Institute, Trinity College of Nursing and Schools of Allied Health, the Quad Cities Graduate Study Center, Marycrest International University, St. Ambrose University, and the Palmer College of Chiropractic are among the many institutions offering educational advancement.

Several difficult issues have faced a school district that attempts to include community members in the decision-making process. Among these issues were the possible construction of an intermediate school, renovation of an intermediate school for the purpose of converting it into a high school, and reduction of class size.

Currently facing the school district members are a number of concerns. These topics include a review of district facilities with an emphasis on accessibility for the physically disabled; improvements in media centers of elementary schools; the addition of an athletic field; improvements at the facility which houses district alternative programs; and renovation of all buildings to provide computer technology in classrooms. District administrators recognize that a bond referendum will be necessary to fund the school district's needs.

Recently, the district implemented a three-year plan to reduce class size in all elementary schools. As part of this initiative, the school board mandated grade level restructuring for sixth and ninth grades respectively; sixth graders were moved from elementary buildings to intermediate buildings, and ninth graders were moved from intermediate buildings to the high schools. In addition, administrators addressed the need for changes to attendance boundaries.

National Context

A recurrent theme evidenced in educational literature throughout the United States is that many students lack knowledge of reading strategies applicable to science text which might facilitate their comprehension of textual material. Spence, Yore, and Williams (1995) stated, "It is widely believed that science reading comprehension and reading strategies could be enhanced by explicit comprehension instruction embedded in the normal science instruction by the regular classroom teacher" (p. 2). Teachers need to utilize with students the learning activities that address specific comprehension strategies inherent in science textual material.

Students who are actively engaged in learning activities that emphasize transfer of reading strategies across disciplines may manifest increased interest and motivation in the subject matter. As stated by DiGisi and Willett (1995), "Science and reading educators need to provide science policymakers and teachers with effective techniques for integrating strategies for constructing meaning from science text into their science curriculum for students at all academic levels" (p.138). Through coordinated efforts by reading teachers and science instructors to integrate specific reading strategies to content in the science textbook, students are likely to experience transfer of understanding, thereby creating a positive impact on their academic achievement.

If students can demonstrate a proficient level of application of reading strategies across disciplines, they are more likely to manifest increased motivation to learn. "Students who are highly motivated with intrinsic goals will be more thoughtful, deliberate, and persistent in their literacy learning" (Guthrie & McCann, 1997, p. 138).

Thelen (1984) asserted, "Helping science teachers to guide student understanding of today's world and prepare science students to meet unknown questions of tomorrow's world is difficult, but necessary" (p. 49). Through collaborative efforts of educators in reading and science curricula, problems associated with students' underachievement in science will be more effectively and efficiently addressed. Opportunities for students to experience transfer of skills across the disciplines may be realized.

CHAPTER 2

PROBLEM DOCUMENTATION

Problem Evidence

Apparent to a team of teachers at the targeted intermediate school was that a number of sixth grade students were underachieving in science as compared to other disciplines. Students' science test scores appeared lower than their test scores in other subject areas. Some students demonstrated a lack of class participation, while others complained they were having difficulty reading and comprehending the science textbook. Science teachers observed that many students lacked the motivation to succeed.

One method utilized by science instructors to measure student achievement in science class was to monitor students' grades. Scores from assessments were categorized as follows: tests and quizzes, projects and labs, daily work, and class participation. Each of the four categories amounted to 25% of the student's total science grade for the marking period.

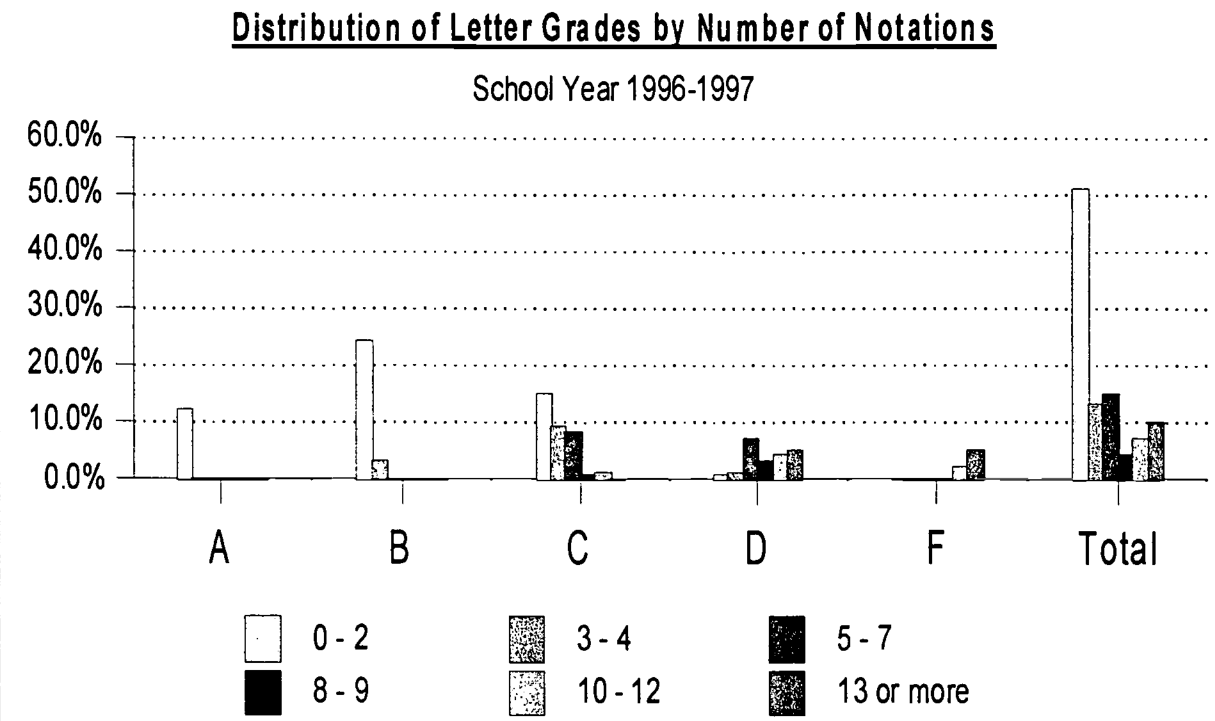
To examine students' class participation and motivation, science instructors utilized a notation system. Notations were subdivided into three sections. These divisions were: being on task, completing assignments, and being prepared for class. Whenever a student did not meet a categorical criterion, the teacher administered a notation to that student. Notations served as reminders to students that behavior should be altered. Because of the nature of the criteria, it was possible for students to receive multiple notations in one day.

Science teachers tallied the number of notations per student in the class participation category at the end of each marking period. This tally was then converted to a letter grade as follows: 0-2 notations equaled (=) A; 3-4 notations = B; 5-7 notations = C; 8-9 notations = D; 10-12 notations = F; and more than 13 notations = 0.

Science teachers also assessed students' academic work. Instructors developed rubrics to score students' academic work in the categories of tests and quizzes, projects and labs, and daily work. Rubric scores were converted to letter grades as follows: 5 rubric points equaled (=) A; 4 = B; 3 = C; 2 = D; and 1 = F. On some occasions, science teachers scored students' papers with a ✔+, ✔, and ✔- and converted these to numeric values as follows: ✔+ was equivalent to 5 points; ✔ equaled 3 points; and ✔- equaled 1 point.

At the conclusion of the marking period, when grades from the four categories were combined and averaged, scores were often in the form of mixed numbers. As a result, a new grading scale with a numerical precision to the tenths place was developed. This is described as follows: 5 to 4.5 = A; 4.4 to 3.5 = B; 3.4 to 2.5 = C; 2.4 to 1.3 = D; and 1.2 to 0.0 = F.

A question was raised as to whether those science students who earned the greatest number of notations would be the same students demonstrating underachievement in science class. Figure 1 was developed to summarize the number of notations earned by science students compared to their letter grades earned.

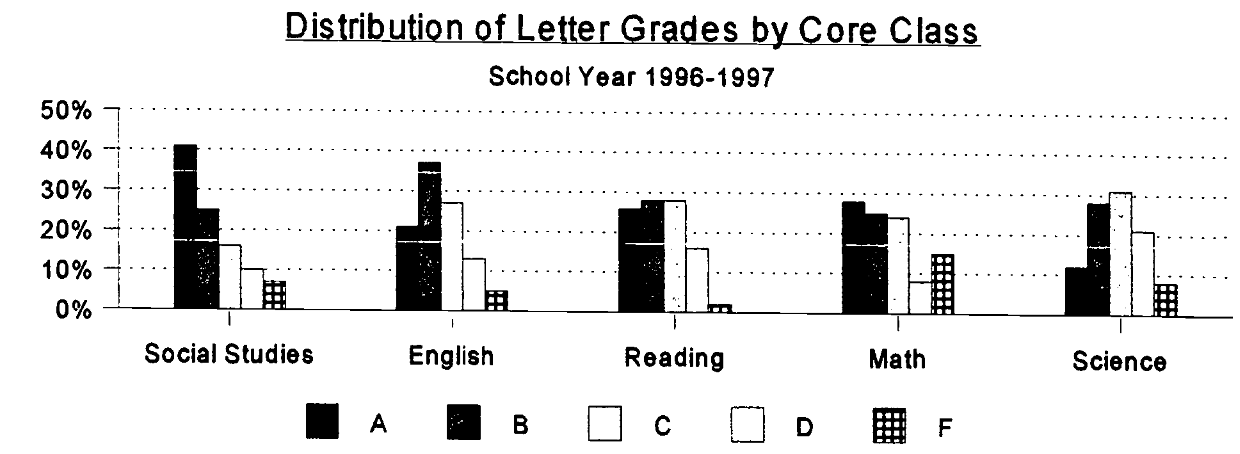


0 - 2	12.0%	24.0%	15.0%	0.5%	0.0%	51.0%
3 - 4	0.0%	3.0%	9.0%	1.0%	0.0%	13.0%
5 - 7	0.0%	0.0%	8.0%	7.0%	0.0%	15.0%
8 - 9	0.0%	0.0%	0.5%	3.0%	0.0%	4.0%
10 - 12	0.0%	0.0%	1.0%	4.0%	2.0%	7.0%
13 or more	0.0%	0.0%	0.0%	5.0%	5.0%	10.0%

Figure 1. Distribution of letter grades by number of notations (school year 1996-1997).

Revealed in the data was that 79% of the students in science class earned 7 or fewer notations; of those students, 89% earned grades of A, B, or C. Further analysis indicated that 21% of the students in science class received 8 or more notations; of those students, 93% earned grades of D or F. There was an apparent connection between the number of notations earned by students and their academic achievement.

Figure 2 shows a comparison of letter grades students earned in science to letter grades they earned in other core subjects.



A	41%	21%	26%	28%	12%
B	25%	37%	28%	25%	28%
C	16%	27%	28%	24%	31%
D	10%	13%	16%	8%	21%
F	7%	5%	2%	15%	8%

Figure 2. Distribution of letter grades by core class (school year 1996-1997).

Researchers concluded that many students were not as successful in science class as compared to other disciplines. In science, which traditionally has a non-narrative text, a greater number of students earned average or below-average grades than in other curricula.

Based on the results of Figure 1 and Figure 2, two conclusions were apparent. For students in science class, a relationship existed between academic grades and number of notations earned. In addition, when comparing students' science achievement to their success in other content areas, evidence indicated that students were not achieving as well in science class as they were in other disciplines.

Probable Causes

Students may be underachieving in science class based on four probable causes:

1. Students do not know how to read nonfiction text for understanding.

2. Students' reading abilities may be incompatible with vocabulary/comprehension levels of the science textbook.

3. Students are not applying comprehension skills they learn in reading class to activities in science class which foster transfer of those skills.

4. Students do not see a connection between what they are learning in science and events in their lives.

The degree of students' science class participation was determined through teacher observation and notational records. Some students did not contribute to group discussions. When instructors assessed students' science project work and daily activities, they ascertained that much student work was of substandard quality.

Science instructors compared notational records to students' academic grades in science class. This comparison revealed that students who earned D's and F's in science class received 72% of all notations administered; these notations were for infractions such as not being on task, not being prepared for class, or not doing homework. The average score for science class daily assignments was C minus. Evidenced through teacher observation and notational records was that those students who were underachieving in science class were the same students who were not on task during science class discussions and activities

Science teachers assigned readings of text as homework. A number of students were not completing those readings. Teachers examined the 1996 Iowa State of Basic Skills (ITBS) composite reading scores for students in sixth grade. The general sixth grade student population were reading at a fifth grade-six month reading level. In order to compare students' reading levels to the readability level of the science text, instructors administered the Flesch Reading Ease Formula (Singer & Donlan, 1989) to passages of the science textbook; readability levels of the selected passages examined were determined to be at grade seven and above. These teachers concluded that students who read below grade level, as well as some students who read at grade level, may experience difficulty reading and comprehending the science text.

During the fourth marking period of the 1996-1997 school year, sixth grade students earned an average science test grade of C minus. Members of the research team sought to determine whether students were applying skill strategies learned in reading class to material they were learning in other classes. Science teachers and the reading instructor identified a specific reading skill that was taught in reading class and that students should have directly applied to an activity assigned in the science classroom. This skill was "following directions."

Teachers selected a representative sampling of students from the previous year who were in both the reading class and science class. The reading teacher reviewed students' scores on the posttest "following directions"; this posttest was part of a resource packet provided as part of the district-adopted reading series. Evidenced was that 91% of all students in reading class earned an A, B, or C on the "following directions" posttest.

Science instructors reviewed grades those same students had earned in a science activity teacher-designed to foster students' application of "following directions." Science teachers, however, noted that only 66% of that same student sampling transferred knowledge of "following directions" to the teacher-developed science activity, thereby earning an A, B, or C grade. If this one student sampling indicated such a large disparity in degree of skill transfer, instructors questioned whether students would have difficulty with skill transfer in a majority of their science assignments. Would it be possible for reading and science teachers to target specific skill instruction that would foster students' transfer of understanding?

Determining probable causes for students' underachievement in science has generated concern on a national level. The importance of students being able to read the science text in order to experience success was affirmed by Wright (as cited in Thelen, 1984), ". . . much science content knowledge must be gained through reading. As with most academic subjects, reading is a vital tool for the successful science student" (p.1). "How does one tie in the science of reading with the reading of science?" (Duran, 1990, p.25)

Although reading teachers teach students numerous strategies applicable to nonfiction text, science teachers complain that students are not demonstrating this transfer of understanding. If students do not perceive when, or perhaps how, to utilize a strategy learned in reading class to material in other subject disciplines, it is probable the student will not demonstrate successful transfer. Edmondson and Novak (1993) stated, "Students are very skilled at adapting their learning strategies to achieve 'success' in their classes, but little of what they learn is meaningfully integrated into their existing conceptual frameworks" (p. 548). Consequently, students may achieve success in reading class and simultaneously fail in science class.

Tei and Stewart (1985) addressed the problems associated with students' lack of comprehension of textual material. "Because one science text is typically used for all students in a class, mismatches occur between reading competence and reading demands for many children" (Chall, Conrad, & Harris-Sharples, 1991; Meyer, 1991, as cited in Morrow, Pressley, Smith & Smith, 1997, p.57). If science teachers utilize a single text, it is probable a number of students may lack the ability to read and comprehend that text. How can teachers address the reading competency levels of all students?

Students who say,"I don't care about this," or "What does this have to do with me?" are of concern to researchers. "It is self-evident that all students are motivated in some way. For the teacher facing 25 to 35 students in 5 or 6 classes each day, the question quickly becomes, 'Motivated to do what?'" (Kindsvatter, Wilen, Ishler,1992, p. 128). "Many times the content has value and relevance, but students fail to develop insights that connect their lives and their learning" (Smith & Johnson, 1994, p. 198). What happens to these students who make little connection between the content they are learning at school and events in their lives?

> Helping students develop proficiency in the use of interpretive comprehension skills such as are required for reading mathematics and science content becomes, at once, both a means for continuation of technological progress by societies and a dimension of the kind of literacy needed by many individuals for living and working successfully in the late twentieth century (Strain, 1984, p. 3).

Educators are obligated to seek solutions to problems related to students' underachievement in science. To demonstrate success in content area classes, students must be familiar with a repertoire of reading strategies. They must be able to determine when and how to apply each skill learned. Through continuous application and practice of the skills, students will more likely achieve transfer of understanding. For learning to be "real," students must perceive connections between material studied in one class and that explored in other disciplines; perceiving those relationships may foster students' degree of class participation and motivation to learn. Students must sense relationships between what they learn in school and events in their lives. Once students have conceptualized these connections, only then might they choose to become life-long learners.

CHAPTER 3

THE SOLUTION STRATEGY

Literature Review

"Understanding basic science concepts is essential to participate fully in life; however, there is evidence that many students do not acquire this knowledge" (American Association for the Advancement of Science [AAAS], as cited in Morrow, Pressley, and Smith, 1997, p. 57). Teachers are frustrated individuals. They use textbooks and supplemental resources extensively to plan lessons; they encourage diversity of thought among students; they read the latest research to become knowledgeable about current teaching practices and theories. Yet, test results do not demonstrate that students are achieving mastery of the material so carefully and painstakingly presented. Teachers are continually asking why students are underachieving in science. As professionals, teachers are constantly seeking solutions.

One reason students are underachieving in science may be because they do not know how to read nonfiction text for understanding. Many teachers observe that students are unable to answer questions related to the text's content, that students do not perceive that science lessons are interconnected, and they seldom ask or answer questions requiring the use of higher-order thinking skills. Teachers may complain that the quality of student work is substandard, that students demonstrate low motivation in the science class, and that students seldom select books about science to read in their free time.

Knowing how to examine a nonfiction text for its organizational structure can be helpful to students who have difficulty reading textual material in content areas. Because students are most familiar with narrative text, such as storybooks and novels, they must be taught how to familiarize themselves with text structure of nonfiction books used in content area courses, such as science textbooks.

Cronin, Sinatra, and Barkley (1992) described a comprehensive plan to help high school students understand text organization by using semantic mapping. Semantic mapping, sometimes referred to as webbing or clustering, is a visual tool used to represent the organization of a text. Six styles of text organization were defined as follows: 1) sequential, a text structure that shows events and occurrences in successive order; 2) descriptive, a structure that emphasizes detailed descriptions of material in the text; 3) classificatory, grouping themes by an identifiable classification; 4) comparison/contrast, a structure that shows how things are alike and different; 5) cause/effect, which describes the relationship between a catalyst and the reaction produced by the catalyst; and 6) persuasive/ argumentative, a type of text format whereby the reader must make judgments and formulate opinions related to material presented in the text. Students' proficiency with these mapping styles might also lead to students' improvement in reading comprehension and writing development.

Research by Grossen and Carnine (1992) yielded two additional mapping strategies. Besides the previously described sequential map and the cause/effect map, a descriptive or thematic map might be useful to aid students in identifying main points of a text. This map is similar to an outline and shows relationships between ideas. Also mentioned was the problem/solution map, helpful when students need to describe a problem and propose a solution to it.

Once students have practiced using each type of map, they can modify or create their own maps. The ultimate objective is for students to be able to construct mental maps while they are reading the text. Because cause/effect, compare/contrast, problem solving, and sequencing are skills taught throughout the grades, and because many students need a visual aid to help them understand the teacher's presentation, maps might provide tools students need to help them comprehend the skill being addressed.

Besides mapping, many other visual tools are available which teachers can incorporate into their instruction. In an article by Hadaway and Young (1994), directed primarily to teachers of second language students, numerous graphic organizers were suggested as tools to help students comprehend textual material. Among these were time lines to record events in chronological order, Venn diagrams to show similarities and differences in concepts being studied, H-Maps as a compare/contrast visual tool, flow charts to depict the sequence of events, and graphs or charts to synthesize information. Visual tools included maps and realia. Through writing, students might become involved in a Language Experience Approach or use a jot chart to help them take notes on relevant material. Suggested for vocabulary development was the card sort, whereby students arrange important terms and concepts in a hierarchical order. Trade books, magazines, newspapers, and picture books were mentioned as possible sources from which comprehension activities could be developed.

What other methods can be utilized to facilitate student comprehension of text? Suggested strategies cited by Duran (1990) included Cassidy's content-area reading science kits (CARE) which are used to reinforce a number of reading skills through games and activities, McGeehon's "Thinking Skills," which emphasizes skills focused on students' reasoning abilities, and Guerra's scientific method for teaching reading comprehension. Each of these strategies can provide teachers with instructional methods to facilitate students' comprehension of textual material.

Another strategy a teacher can implement to help students read nonfiction text was developed by Schumaker et al. (as cited in Rhodes & Dudley-Marling,1996). This three-part strategy addresses the skill of previewing chapter titles and subtitles. In the first part of the strategy, called Survey, students examine general text organization, which includes the table of contents, illustrations, and introductory and summary paragraphs. Next, students apply Size-up, a preview of chapter questions, which helps them determine whether or not there is material in the chapter with which they are already familiar. Finally, after reading the chapter, students should initiate Sort-out, using the chapter questions to self-test material read.

Reaffirmed in a study by Kealey (as cited in Duran,1990) was the premise that . .

> At the start of each year, students should receive a thorough explanation of the textbook's function. A discussion of the title, preface, table of contents, appendices, and indices will help students use both the text and the reference materials. Students should be taught how to read graphics and diagrams and be given an explanation of the rationale of chapter

> organization. They will then be able to see interrelationships between chapters and to read objectives at the beginning of the chapter or refer to questions at the end of the chapter prior to reading (p. 25).

Noticing the interrelationships among chapters may, in turn, activate the student's prior knowledge to the material under study; when students apply prior knowledge to unfamiliar science concepts, they will more likely experience a transfer of understanding.

Previewing targeted vocabulary words is an additional strategy proposed in the literature to address problems associated with students' inability to read nonfiction text. As suggested by Carter and Klotz (1991), prior to having the students study a chapter, the teacher should give the students a list of vocabulary words they will need to understand content material in that chapter. There are specific strategies a teacher can use to help students learn words with multiple meanings, sight words, and words whose meaning can be determined through context clues.

The content area teacher has the responsibility to teach the specialized meaning a word might have in a particular course. One example of a word whose meaning varies depending upon the way it is used in a particular subject is the word "volume." Volume may mean a book, a series of books, the space an item occupies, a large amount of something, as well as the quantity of sound. Before students can understand the meaning of the word "volume," they must examine it within the context of the sentence in which it is used in a particular subject area. In an article addressed to science teachers, Walker (1989) stated, "We should all be reading teachers to some extent, and precisely because the terminology is so very familiar to us as science teachers, we must not allow ourselves too much reliance upon 'osmosis' during the reading process itself" (p. 135).

In addition to addressing words with multiple meanings, the teacher must make the students aware of specific sight words necessary for mastery of chapter content. Drills or games might be utilized for this purpose.

Students should also have practice determining meanings of unfamiliar words by using contextual clues. If a student tries to identify the meaning of a word by using contextual clues and is unsuccessful, reference to the dictionary and glossary of the textbook may be helpful.

Moore and Moore (as cited in Stahl & Kapinus, 1991) suggested the use of Possible Sentences, a strategy teachers can utilize to help students predict word meanings in content area courses. The teacher selects six to eight vocabulary words related to key concepts in the text that might cause difficulty for the students and an additional four to six words familiar to the students. Students can utilize these ten to fourteen words to generate sentences on the chalkboard that relate to chapter content. At this point, teachers should not be concerned with students' accuracy, or lack thereof, to compose sentences demonstrating mastery of vocabulary. Possible Sentences is a method for students to predict meaning of vocabulary related to subject matter they are going to read. Following the reading of the text and based on the material read, students discuss whether each student-generated sentence could or could not be true. If a sentence could not be true, discussion should follow as to how the sentence might be modified to make it true.

In addition to the strategy of previewing vocabulary, Carter and Klotz (1991) suggested the use of two kinds of teacher-developed instructional guides to help students facilitate recognition of text organization. These guides are the organizational guide and the concept guide.

Students can use an organizational guide to differentiate among the types of organizational patterns found in texts. These patterns include: a) numeration, which is the process of presenting an idea and immediately supporting it with additional information; b) relationship organization, whereby the relationship pattern becomes apparent through writing schemes such as cause/effect, compare/contrast, division and classification, and directions or sequencing that relate ideas to each other; c) problem solving, the most difficult pattern because the student must read to solve the problem; and d) the persuasive pattern, which relies upon propaganda techniques to influence the reader's ideas (Carter & Klotz, 1991).

The second type of guide is the concept guide. A teacher develops it by pre-reading the text and extracting important concepts. From these concepts, the teacher then writes exercises and formulates comprehension questions. The students use the exercises and questions as they read the text, which may lead to an increased comprehension of textbook material (Carter & Klotz, 1991). If students use instructional guides and apply strategies such as previewing the title, subtitles, and vocabulary words, they may find it easier to read and comprehend nonfiction text.

A different type of guide, or mapping strategy, was described in an article by Wood (1988). It is called The Reading Road Map. The teacher chooses the most important information in the chapter, designs questions and activities related to the relevant concepts, and draws a map which includes reading rate indicators to guide the students reading of the chapter. The Reading Road Map "helps students read a passage at different speeds to coordinate with different purposes for reading" (p.24).

A seven-step strategy by Singer and Donlan (1989) can be utilized by teachers who wish to enhance classroom instruction but are faced with a single science textbook. Teacher may employ these steps:

1. Do a task analysis. Outline the concepts to be stressed and processes students will need to master the content.
2. Give an entry level test to determine the students' background knowledge.
3. Write classroom objectives.
4. Give the students a chapter overview, which includes expectations of content to be studied.
5. Review difficult vocabulary.
6. Teach the students needed thought processes, such as cause/effect, compare/contrast, and sequencing.
7. Guide students while they are reading by using guides consisting of proposed questions based on textual content and glossing, the writing of marginal notes, word definitions, paraphrasing, and posing of questions (p.383).

By directing students' learning as they study the chapter, the teacher will more likely become aware of textual difficulties students encounter and will be able to modify lesson plans to address those problems.

The strategy of reciprocal teaching proved to be of benefit to students in a study conducted by Palinscar and Brown (as cited in Harder, 1989). After students read assigned text, adult tutors taught them to paraphrase, summarize, and anticipate questions which would lead them to make predictions about the part of the text to be read next. "A key to the effectiveness of this strategy is adjusting the task demand to support the students when difficulty occurs"(Vacca & Vacca, 1996, p.1).

Scan, Plan, Act, and Revise (SPAR) is an additional technique students can utilize to monitor their own comprehension of text (Harder, 1989). Students learn to scan for key concepts, identify the strategies they will use to comprehend the text, practice the strategies in class, review where they were successful, and revise strategies as needed.

Harder also suggested numerous comprehension strategies a teacher might model to help students increase reading comprehension of textual material. These included summarizing, paraphrasing, identifying key words, diagraming, charting, outlining, reading for different types of information, and mapping/making flow charts. Through guided discussions, small group sessions, and use of self-testing techniques, students may become more involved with their own learning. "When students monitor their reading comprehension strategies, they also demonstrate that they can take responsibility for their learning process" (p. 211).

Whose responsibility is it to teach the reading strategies? "The most qualified individual for content-reading instruction is the content teacher" (Duran, 1990). This concept was confirmed by Gaskins, et al. (1994),

> By teaching students during science classes how to use reading and writing as tools to learn and understand scientific concepts, students can be prepared to deal appropriately with science-related issues that will arise throughout their lives" (p.1040).

However, it is the responsibility of every teacher to provide opportunities for students to practice the strategies identified as relevant to the textual material under study. As stated in an article by DiGisi and Willett (1995) who examined how biology teachers described their instructional use of reading and textbooks,

> "We need to help teachers integrate active reading strategies (e.g., monitoring comprehension, connecting reading to prior knowledge, constructing understanding) into an interactive-constructive model of science instruction where students ask questions, explore concepts through hands-on activities, record and analyze data, read texts using active comprehension strategies to create new knowledge or develop further questions, and extend their learning through discussions in the social context of the classroom" (p. 137).

Tierney and Pearson (1981) were also proponents of structuring activities that allow students to practice strategies until those skills become an inherent part of their learning. They stated,

> "Situations and activities need to be implemented wherein students can try, discuss, and evaluate their strategy, skills, and knowledge utilization across

> a variety of 'relevant' reading situations. In this regard, teachers need to move beyond merely mentioning reading comprehension skills and begin helping students learn how to learn" (p. 30).

To provide the numerous opportunities necessary to foster success in the science classroom, teachers must provide students time for structured practice of science activities that utilize comprehension strategies. To insure this needed practice, teachers may utilize whole class instruction, permit students to work individually, team students with peers, encourage work in small groups, or engage the students in a combination of organizational patterns.

One researcher determined that during the act of reading, students utilize two elements of learning, the cognitive, which includes comprehension, interpretation, and assimilation, and the affective, which includes interest, self-confidence, control of negative feelings, and willingness to take risks (Frager, 1993). "There is an affective dimension to even factual, nonfictional account. Effective strategies combining affective and cognitive elements of instruction can motivate students to read content area textbooks with awareness" (p. 616). Several suggested Instructional methods using cognitive and affective elements to help students develop confidence, monitor their feelings while reading, and share and extend their comprehension were presented.

If students are interested in what they are studying, they are more likely to comprehend and retain the material. Mathison (1989) stressed the importance of student interest in content area reading. "Helping students create a more compelling and purposeful relationship with their textbooks will certainly facilitate their ability to learn in our classrooms (p. 175). Among suggested strategies teachers might employ were the following: using analogies, relating personal anecdotes, disrupting readers' expectations, challenging readers to resolve a paradox, and introducing new and conflicting information.

When students are interested in the textual material, they are likely to continue reading the text even when they encounter comprehension difficulties. Through persistent effort, students gain confidence in their ability to address those difficulties. The importance of students' self-confidence as problem solvers and decision makers when reading science text was affirmed by Craig and Yore (1996). Teachers should provide students with instruction in three dimensions: the nature of science, the nature of science texts, and the nature of science reading. This instruction should be deliberate and explicit so that students' understanding of these concepts becomes intrinsic.

> These students should be involved in developing strategies and guidelines for their use in resolving difficulties; and these strategies and guidelines should be conscious, flexible, and diverse enough to be efficient and effective in a variety of circumstances (p. 236).

Instructional practices which access students' prior knowledge, modeling, guided practice, consolidation, and independent practice are among those strategies teachers may employ to address students' difficulties with textual comprehension.

Throughout the learning process, the teacher should encourage students to use reflective thinking. According to Perkins and Swartz (1992), "Just as students often do not transfer content knowledge, they often do not transfer ways of thinking that they have learned in a particular class. What can be done?" (p. 66) The authors suggested two approaches to teach for transfer: hugging, whereby students practice direct application of a process, and bridging, in which the students make generalizations and anticipate possible applications.

The importance of reflective thinking was emphasized by Edmondson and Novak (1993) in their research:

> By emphasizing the active role of the knower in the construction of knowledge and encouraging students to reflect on their learning, educators invite students to move away from rote learning strategies and toward more meaningful ones. By being sensitive to students' attitudes about science and the quality of their learning in our laboratories, educators are able to identify areas for improvement (p. 557).

Two educational tools which facilitate reflective thinking were suggested by Burke (1994). These are the learning log and the student journal. Learning logs are brief, factual, and objective entries made by students to record their learning. Journals are more subjective narratives that include feelings, opinions, or personal experiences.

Teachers may direct students to write in the learning log or journal at the beginning of a lesson, during instruction, or at the conclusion of the unit. When the learning log or journal is used at the beginning of the unit, students may, through their writing, tap prior knowledge and assess what they already know about the subject matter to be studied. When teachers ask students to write in the learning log or journal during lesson instruction, students will more likely record their understanding of lesson concepts. Fusco and Fountain(1992) commented that feedback at this time may be useful to both student and teacher; it serves to give "the teacher direction as to what to do next based on where the students are in their level of sophistication with the lesson ideas" (p. 248). When students utilize logs or journals at the conclusion of a learning experience, they clarify "the essential meanings and characteristics of operations, so that they can be generalized to other kinds of situations"(Barell, 1992, p.261).

Burke (1994) documented the advantages of reflective thinking. Among these were the following:

1. Students will retain key ideas.
2. Writing skills will improve.
3. Students with special needs will have more time to process information when they use reflective logs.
4. Interaction among students will increase.
5. Students can study logs for quizzes and tests.
6. Learning logs can be included in portfolios.
7. Teachers can assign grades for selected logs or 'Log Books' (daily grades or weekly grades).
8. Students who are absent can get logs from friends to keep up with work they missed.
9. Teachers can ascertain <u>during</u> the lesson if there is confusion or misunderstandings about information.
10. Teachers don't just 'cover the curriculum.' They select the most important information, and then they see if students understand it before the

final test. (p. 85).

Reflective thinking, in turn, may lead to reflective discussion, which requires the use of higher-order thinking skills. Wilen expressed that, "Students solve problems, clarify values, explore controversial issues, and form and defend positions during reflective discussions" (as cited in Kindsvatter, Wilen, & Ishler, 1992, p. 182). Teachers increase classroom interaction through the use of questioning techniques to get students involved in moving from convergent thinking, or the use of prior knowledge, to divergent thinking, which engages the higher-order critical/creative thinking processes. Verbal, as well as nonverbal, behaviors such as voice quality, movement, lesson pace, facial expressions, eye contact, proximity to students, and variation of the instructional mode are techniques that can be applied to classroom management to enhance students' enjoyment and interest in the subject. Effective teachers use strategies such as wait time; they ask students to clarify, expand, and support their responses; and they encourage students to formulate questions related to the textual material which will stimulate higher-order thinking (Kindsvatter, Wilen & Ishler, 1992).

The same strategies teachers of science apply to their discipline to help students comprehend textual material are useful to students in other disciplines. Therefore, principals may wish to become involved with monitoring the use of successful instructional strategies in the classrooms. When principals become familiar with useful strategies that have direct application to all disciplines, they can promote effective staff development, are better qualified to assess teacher performance, and may inspire all teachers to become teachers of reading (Carter & Klotz, 1991).

Another possible reason students may be underachieving in science is that vocabulary/comprehension levels of the science text may be incompatible with students' reading abilities. Because most school districts require use of a specific textbook, and because some students enter a grade with their reading levels not yet sufficiently developed to enable them to read the textbook for understanding, teachers must seek solutions that will help students comprehend the textual material. According to Baer and Nourie (1993), " . . . effective teaching becomes, to a certain degree, a matter of being able to manage the achievement differences among children successfully" (p. 121).

The selection of a science textbook is generally made by recommendation from a committee whose members are composed of teachers, curriculum coordinators, and parents of the school community. The committee members review textbooks from various educational book companies. Readability level of text, clarity of graphic organizers, availability of teacher resource materials, and formatting of text are among items considered by the selection committee.

One problem encountered by the science teacher is that the readability of the science text, even after careful scrutiny by the textbook selection committee, may be incompatible with the reading levels of many of the students. This can affect both student comprehension of textual material and degree of student motivation to complete assigned textbook readings and related activities. As stated by Santiesteban and Koran (1977),

> "Students with low verbal ability and low motivation remain the largest segment of the school population to which we are attempting to teach science. At the same time, written materials, in the form of science texts,

> laboratory guides, and worksheets, still occupy a major place in science instruction. A number of the science curricula for low-ability students still stress the written word as the vehicle for knowledge acquisition. The use of written materials for the purpose of science instruction should continue, for it is difficult to imagine how a student can learn to read and learn from reading without reading (p.54).

That students may be expected to read and comprehend materials beyond their capabilities was affirmed by Baer and Nourie (1993). "Certain students are thus relegated to failure from the start because they are expected to read content materials that go beyond their ability" (p. 121). Teachers must seek strategies to deal with the issues of keeping students motivated to learn, meeting the school district's science goals, and trying to accommodate a science textbook's readability level to the individual student's reading ability.

How do children learn to comprehend science text material? The heuristic model and measurement models were designed by Meyer and others (1985) as part of a seven-year investigation to determine how students learn to comprehend what they read. The heuristic model, based upon studies of effective teaching, included eight constructs: entering student ability; instructional materials characteristics; classroom management; instructional feedback; instruction in decoding, comprehension, and science; stable home characteristics; home support for literacy and science knowledge; and student ability at the end of kindergarten. Measurement models for the eight constructs were developed. Because these measurement models reflect effective strategies that facilitate comprehension of text, they could serve as reference tools for teachers as they design lesson plans and student outcomes for classroom instruction.

Whether comprehension can be taught was also the concern addressed by Haller, Child, and Walberg (1988). Through the process of compiling and synthesizing the results of twenty studies related to metacognitive instruction on reading comprehension, they determined that "metacognitive instruction was found particularly effective for junior high students" (p. 5). Suggested effective instructional approaches that teachers might use in the classroom setting included teaching the students the strategy of self-questioning, helping students become aware of textual inconsistencies, and using various methods of instruction, such as lectures, demonstrations, feedback, and handouts.

Teachers should consider that students' ability to comprehend text is affected by their ability to reason. Vachon and Haney (1983) described two levels of reasoning ability - the concrete and the formal. "Curriculum materials must be provided that are appropriate for reasoning levels of the students if they are to serve as the basis for intellectual development and to prevent apprehension on the part of the learner" (Vachon & Haney, 1983, p.244). Students' reasoning patterns must be analyzed and interpreted before techniques can be determined which will enhance reading comprehension (Karplus, 1979, & Karplus et. al., 1977, as cited in Vachon & Haney, 1983). Middle school students appear to operate at the concrete reasoning level (Kolodiy, 1977, & Herron, 1975, as cited in Vachon & Haney, 1983).

> The concrete operational level is the stage of cognitive development in which a student can use identifiable and reproducible thought processes called

'reasoning patterns' to solve problems related to classification, serial ordering, reversibility, and conservation of quantity. The concrete thinker is confined largely to perceptible objects and events, whether or not they are actually present (p. 237).

The formal reasoning level is an extension of, and further development of, the concrete level. It is the "highest level of cognitive development. The individual can reason in terms of abstract entities and hypothetical situations and has the ability to apply theoretical reasoning, interpret functional relationships, interpret observations, control variables and form theories" (Karplus, et. al.,1977, as cited in Vachon & Haney, 1983). In order to maximize transfer of learning, curriculum materials appropriate to the students' reasoning abilities should be selected and utilized in the classroom.

Various curricular materials and suggested teaching practices useful to teachers seeking effective techniques to address meeting students' needs when the science textbook is too difficult for them to read were presented in an article by Baer and Nourie (1993). These included lecturing, having peers rewrite the textual material to an appropriate reading level, using supplemental texts and audiovisual aids, building in-class vertical files, encouraging small group work, supplementing the text with trade books, and recording the text. "Changes in teaching behaviors and accommodations of materials must be made to assure that all children have a legitimate opportunity to succeed in learning the content" (p. 122).

Teaching specific skills such as main idea, context clues, and summarizations is integral to one strategy posed by Spence, Yore, and Williams (1995):

> During reading, students were taught to monitor their comprehension and recognize when they were not understanding the gist of the text. By paying attention to the main ideas as they read, using context to discern word meaning, and summarizing paragraphs and passages after reading, the students began to understand how these reading strategies help them make meaning of what they are reading (p.31).

Because main ideas, context clues, and summarization are reading skills targeted by reading teachers and which are also present in content subject matter, teachers should help students become familiar with these skills to the degree that students will be able to recognize when to apply each skill as it is needed in textual readings and confidently make that application.

When students are unsuccessful readers, they may become bored, anxious, and unmotivated to change their behaviors. In a study by Mallow (1991), various strategies were presented to address the problems of student science anxiety, science avoidance, and science illiteracy. Students should be taught to a) orient themselves to the lesson by using objectives, b) read slowly and reread, taking notes, c) use questions to self-test, d) use chapter problems and make up one's own exercise and solve it, and e) self-assess writing quality. Special mention was made that students should read a science chapter three times; readings should occur before the class session, during the coverage of the chapter, and at the conclusion of the chapter study. For those students who might find it impossible to read the text, teacher read-alouds, peer readings, and tape recordings of specific chapters are among solutions a teacher might consider when preparing the assignment.

Can average readers be taught effective strategies used by gifted youngsters to help them comprehend textbook material? In one research report by Fehrenbach (1991), a group of students used think-aloud analysis to verbalize strategies they were using during reading. Analysis of protocols in fourteen classifications revealed that gifted students used the skills of rereading, inferring, analyzing structure, watching or predicting, evaluating, and relating to content area more than their average-reader counterparts. These results suggested that it might be beneficial if the classroom teacher would develop and teach these effective strategies to all learners.

One further strategy that could be used to address the problem of the students' inability to read the textbook is the use of advance organizers, adjunct questions, and behavioral objectives. Advance organizers are sets of written materials that introduce the most important concepts of a passage (Ausubel 1960, 1968; Novak, Ring, & Tamir, 1971; as cited in Santiesteban & Koran, 1977). Ausubel found that students were more successful with science material when they were given an opportunity to become familiar with general concepts before they were taught in the classroom. This provided students with background knowledge for more complex material presented at a later time (Ausubel, as cited in Thelen, 1984).

Asking questions related to the reading material is one of the teacher's most frequently used instructional methods. Stated by Frase (as cited in Santiesteban & Koran, 1977):

> Adjunct questions are questions imbedded within the written material. Presented after a written passage, the adjunct questions theoretically review

> what has been read and serve as reinforcing stimuli. Adjunct questions presented before a passage or paragraph 'forward shape' the readers' mediating processes, thereby increasing the attention given to important aspects of the communication.

However, Herber and Nelson (1975) advised caution when questioning is used if students do not possess the reading skills necessary to respond successfully to the questions. Teachers must determine whether questioning is an acceptable strategy. Consider their argument:

> When one directs students' reading with questions, there is an implicit assumption that students already have the reading skills necessary for a successful response to those questions. If the students do indeed possess those skills, then such questioning is perfectly valid. But if students in fact do not already have those skills, then directing their reading with questions that assume they do is misdirected teaching (p.513).

In addition to advance organizers and adjunct questions, the teacher can specify behavioral objectives that can be used before students read the material. This may include examination of text organization. By focusing students' attention on textual material and giving them cues as to the parts of the text that are particularly relevant, teachers will promote student learning (Rothkopf, as cited in Santiesteban & Koran, 1977).

What can be done in the school to persuade all faculty members to share in the responsibilities of teaching reading/study skills which will transfer across the curricula? As described in a study by Simmers, Wolpow, Farrell, and Tonjes (1991), at one school students were asked what study skills they felt it would be important to know. The students' list included listening and following directions, note-taking and note evaluation, using textbook aids, and writing a bibliography. The faculty then directed their efforts towards teaching those study skills and, subsequently, exchanging strategies for introducing and reinforcing them in the daily lessons across the disciplines. They held "Conspiracy Days," whereby all faculty members 'conspired' to teach one agreed-upon reading/study skill in their subject area that day. Using such a school-wide activity provided a first-hand opportunity for students to experience direct application of specific skills throughout the curricula.

Educators will continue to be faced with the dilemma of trying to teach specific subject matter from a single textbook to a classroom of students with various learning abilities and disabilities. Within these parameters, teachers must be creative and employ educational approaches designed to meet the needs of all students.

Students may be underachieving in science because they do not see a connection between the science curriculum and their lives. Teachers observe that students lack motivation to study. Students complain that they are bored and uninterested in the material. Their work may be of poor quality. Teachers observe that during class discussions, students' contributions often do not reflect that students are making connections between the subject matter being studied and events in their lives.

"Students need science that involves ideas and experiences they can use in their daily lives that helps them understand and deal with real world issues (Yager as cited in Ogens, 1991). One proposed strategy involves the integration of literature into the content area curriculum. Smith and Johnson (1994) identified three models of instruction which provide a framework for teachers to use when implementing literature in the content studies. The first model is called the single-discipline approach. It uses narrative as the primary source of instruction and the text as the secondary source. In this approach, a thematic learning cycle is developed which includes such strategies as read-alouds and Sustained Silent Reading (Edelsky, Altwerger, and Flores as cited in Smith & Johnson, 1994).

A second model of instruction is the interdisciplinary literature model. Teachers organize skills, concepts, and questions from more than one discipline around a central theme. They design authentic learning tasks. These tasks help students perceive the interrelationship among subject areas.

The third model of instruction is called the integrative literature model. In this strategy, a central theme is also used as a focus. However, the integrative model combines a student's personal concerns with the larger issues that face our world. According to Smith and Johnson (1994):

> Implementing literature within an integrative curriculum model sets the stage for students to focus on the human condition (Smith and Johnson, 1993a) and to develop those living skills (Beane, 1991) essential to understanding and assimilating the enduring but elusive ideas of democracy, human dignity, and cultural diversity (p.204).

The single-discipline approach, the interdisciplinary literature model, and the integrative literature model are useful to teachers who are seeking ways to make the science curriculum more relevant and meaningful to their students' lives.

Another strategy which may help to foster a connection between the science curriculum and events in students' lives is the use of trade books. Trade books with themes related to subject matter being studied may provide students with background knowledge, as well as spark their interest in the topic. Trade books may be utilized as the main source of reading material for those students reading below grade level or as supplements to a single science textbook.

In concluding statements from a report about the Elementary Science Integrated Project (ESIP), Baker and Saul (1990) suggested that the use of trade books in the classroom helped students make connections between the science curriculum and that of language arts. Because underlying goals in both science and language arts were similar, teachers felt at ease crossing curricular areas of expertise. Cited as examples of similar commonalities were critical thinking skills such as predicting, making inferences, assessing evidence, drawing conclusions, and judging argumentation (Baker & Saul, 1990, as originally Baker, 1991, and M. Padilla, Muth, & R. Padilla, 1991). Through a constructivist approach that promoted the use of hands-on materials and trade books in lieu of the science textbook, teachers were able to develop science as the center of a cross-curricular study. As a result, science time increased, and content area reading skills were fostered and practiced. By using the science curriculum as a focus through which language arts skills were taught and science activities designed and carried out, students were more likely to see an interconnectedness between the curricula and experience a transfer of learning.

Suggested in a recent study was the strategy of integrating literature-based activities and traditional basal reading into the science curriculum. Evidence was apparent that students who received instruction in a literature-based/science classroom read science on their own more often than their counterparts. As concluded by Morrow, Pressley, Smith, and Smith (1997):

> When the literature/science students were interviewed, their enthusiasm for the approach was apparent; they expressed the belief that the integrated approach made reading and writing more interesting and that the integrated experiences increased their understanding of science. One of the most interesting outcomes was that a majority of students in the literature/science group reported that they like science, and the majority of students in the literature-only and control groups reported that they did not like science. The most common complaint in the latter two conditions was that science instruction was boring, an infrequent claim in the literature/science condition (p.72).

Students will more likely learn science when they feel that what they are studying is relevant to events in their lives. Presented in the literature were various strategies teachers might utilize to foster these connections, enhance classroom instruction, and make learning more meaningful. Teachers should select those strategies least threatening to students, model the selected techniques, and help students apply skills that demonstrate mastery of learning.

One additional reason students may be underachieving in science is because they are not transferring reading comprehension skills they are learning in reading class to the science curriculum. Most reading teachers use a basal textbook or, when writing lesson plans, refer to a district-mandated list of reading skills to be taught for a particular grade level. Teachers familiarize students with the frequently-used skills of sequencing, predicting, developing main ideas, and identifying topic sentences. On worksheets, in practice workbooks, and in basal reader stories, students are asked to recognize when and how to apply each skill. However, there are students who evidence success when learning a skill in reading class, but, when asked to apply that same skill to activities in science class, demonstrate an inability to transfer their learning. How, then, can teachers address this apparent lack of transfer of reading strategies to the science discipline?

One strategy to foster this transfer of skills between reading and science was posed by Livingston (1989). He suggested that science teachers apply with their students seven approaches to the reading of the science text. These included the study of textual organization, the encouragement of students' involved discussion of pertinent questions which challenge assumptions about statements in the readings assigned, and the promotion of reading materials on current science issues. Writing of lab investigations, reports on books or articles studied, and student research reports from a variety of sources should be encouraged. Several textbooks for the teaching of a particular subject in science should be made available to accommodate the various reading levels of students.

Integration of subject matter across disciplines may foster students' awareness of how what they study relates to events in their lives. "Learning science means integrating reading, writing, speaking, and math" (Zemelman, Daniels, & Hyde, 1993). Teachers in self-contained classrooms may find the process of integrating skills easier to do than teachers of specialized subject matter. Nevertheless, all teachers should explore the development of integrated, thematic units of study and the practice of collaborative teaching across the disciplines. These generalizations were affirmed by Strain (1984) who stated,

> While it cannot be assumed that transfer of skills learned in general reading in the elementary curriculum will ensue, automatically, when students are required to read mathematics and textual materials in high schools, provisions can be made for immediate transfer of skills from one class to another in elementary classrooms. Teachers of mathematics and science classes at high school level are responsible for the continued development of students' capabilities to read their immediate textual materials effectively (p. 10).

If instruction and reinforcement of comprehension skills are fostered by teachers of elementary and secondary classrooms, students will more likely see relationships between content and skills they have previously learned and those which they are currently being taught.

Thelen (1984) proposed that reading teachers and science teachers work collaboratively ". . . to give the science teachers some strategies to make the textbook an effective tool" (p. 1). "Reading teachers who lack expertise in science should not feel reluctant to work with science teachers . . . because reading teachers have expertise in the reading/thinking process" (p.48). A suggestion by DiGisi and Willett (1995) is . . . "for reading and science education faculty to begin to work together in both research and course development for preservice and practicing science teachers pursuing advanced degrees" (p.138). Through collaboration and continued educational endeavors, teachers will be better prepared to meet the challenges associated with making learning integrated, interesting, and meaningful for all students.

One example of a collaborative effort to integrate subject matter and make learning more relevant to students was described in an article by Lester (1987). Eighth grade teachers designed a twelve week team-teaching research project. Students chose a topic from science, researched it in reading, wrote about it in language arts, and published it in computer class. If students experience such connections among the disciplines, they are more likely to be motivated learners.

A negotiated curriculum model was advocated in a study by Davenport and Jaeger (1995). "In a negotiated curriculum, students have the freedom to make choices, to create personal meaning, to see curriculum as connected to something relevant, and to maintain control of their learning" (p. 61). Teachers began planning the unit by setting goals, taking into consideration students' interests, district's curricular mandates, and parents' concerns. Students gave input to the unit by choosing a subject to study, formulating questions to be answered through subject study, and developing a plan of action. "As a result of the negotiated engagements, students become keenly aware of the standards they are expected to achieve, the products they are to produce, and the criteria for their assessment" (p. 61). By encouraging students to take charge of their own learning, they will more likely find the curriculum personally meaningful.

To help make learning more relevant and meaningful to students, educators should become familiar with ten curricular models designed by Robin Fogarty (1991). These models will help teachers integrate the curriculum and "help students make valuable connections while learning" (p. 61). Among these models are The Fragmented Model, a model with directed focus on a single discipline; The Connected Model, a design connecting one topic, skill, or concept to the next; The Nested Model, a curriculum which targets multiple dimensions of a lesson; The Sequenced Model, units which are taught separately but rearranged and sequenced so that concepts relate to each other; The Shared Model, a design which utilizes overlapping concepts from more than one discipline; The Webbed Model, one in which a theme integrates the subject matter; The Threaded Model, a model which "threads thinking skills, social skills, study skills, graphic organizers, technology, and a multiple intelligences approach to learning throughout all disciplines" (p. 64); The Integrated Model, topics designed using a cross-disciplinary approach; The Immersed Model, a model whereby students choose the area of study so that "integration takes place 'within' learners with little or no outside intervention" (p. 64); and The Networked Model, that which allows the students, through personal interest and expertise, to explore their own avenues of learning.

When readers enjoy the act of reading, they may more easily realize connections between content area subject matter and personal experiences. "If readers enjoy what they are reading and perceive a connection between what they read and their own lives, their interest in the literature is high and their comprehension of what they read is likely to be good" (Gee & Rakow, 1990, p. 341). Presented in an article by Gee and Rakow (1990) were thirty-six practices from which teachers could make selections to improve students' comprehension and enjoyment of reading; these included prereading guidance, direct teaching of comprehension strategies, postreading questioning, and student discussion.

Apparent in the literature were various strategies teachers might utilize to integrate subject matter and help students foster transfer of learning. Teachers must become familiar with instructional techniques applicable to their specific disciplines which can be employed to help students perceive that skills learned in reading are directly applicable to other disciplines. In the words of Carter and Simpson (as cited in DiGisi & Willett, 1995),

> Close examination of reading skills reveals that many are actually inherent in logical thought, and thus represent some of the most fundamental 'tools of the trade' for scientists. To the extent that our students are good readers, then, they will have mastered some of the skills necessary for good science. But, . . . the opposite is also true: to the extent that our students become proficient in the processes of science, they will also become better readers (p. 139).

Reading and science instructors may be plagued with self-doubt about whether or not they have designed the most effective avenues for student learning; they may be concerned that they are not reaching all students. As professionals, teachers are obligated to be life-long learners of educational practices, to be knowledgeable about new developments in subject matter of the specific discipline being taught, and to utilize the most effective strategies available to help students achieve to their potential. As teachers plan their lessons, they must ask themselves these questions: What are the current objectives in the lesson to be taught? What are the most effective strategies applicable to the lesson? What classroom activities should be utilized to foster transfer of understanding? Have the instructional needs of all students been addressed?

> While education in mathematics and science is more important, from national and individual perspectives, perhaps than at any previous time in history, there is also recognition that progress in these fields depends on individuals' abilities to read and think at higher levels of comprehension. The challenge for all teachers, involved, is of such nature that they must understand the nature of the comprehension abilities they are attempting to help students develop, the nature of the writing styles to which comprehension applies, and the wide variety of teaching strategies that can be used for its development (Strain, 1984, p.20).

Evidenced in the literature were numerous viable strategies which teachers may employ to enhance classroom instruction so that all students can achieve a measurable level of success. Teachers must choose methods best suited to their particular content area. Through application of multiple teaching strategies and faculty collaboration, teachers will more likely provide all students with meaningful, interesting, challenging, successful school experiences.

Project Objectives and Processes

Taking into consideration the many strategies available from which to design an effective plan of action to promote positive change among sixth grade science class underachievers, members of this research team concluded that their approach would encompass a combination of diverse strategies. Teachers would instruct students in each of the following techniques: using graphic organizers; identifying text structure; previewing chapter titles, subtitles, and targeted vocabulary; applying specific reading comprehension strategies to activities in the reading and science classrooms; and utilizing reflective thinking.

As a result of reading skills taught by the reading teacher in reading class during the period from September 1997 through December 1997, the targeted sixth grade science students will increase their classroom participation in science class as measured by observation checklists. In order to accomplish this objective, the following processes are necessary:

1. Utilize reading skills lessons that are directly applicable to the science lessons.

2. Teach targeted reading skills within the context of the science textbook.

3. Develop a series of learning activities for science class that require active student participation and demonstration of targeted reading skills' transfer.

4. Develop an observation checklist on which to record student participation in science class.

As a result of reading skills taught by the reading teacher in reading class during the period from September 1997 through December 1997, the targeted sixth grade students will increase the degree of application of reading skills to the science curriculum as measured by reading teacher and science teacher assessment of student work.

In order to accomplish this objective, the following processes are necessary:

1. Utilize reading skills lessons that are directly applicable to lessons in the science textbook.

2. Teach targeted reading skills within the context of the science textbook.

3. Develop a series of learning activities for science that foster application of the targeted reading skills to the science curriculum.

4. Design rubrics to assess students' application of reading skills in the science activities.

As a result of students' application of reading strategies to the science curriculum during the period from September 1997 through December 1997, the targeted sixth grade students will demonstrate an increase in base knowledge of science content as measured by science pretests and posttests. In order to accomplish this objective, the following processes are necessary:

1. Utilize reading skills lessons that have application to the science curriculum.
2. Teach targeted reading skills within the context of the science textbook.
3. Develop a series of learning activities that enrich the science curriculum.
4. Administer science chapter pretests and posttests.

As a result of maintaining records of targeted sixth grade students' daily assignments and test scores in the science class during the period from September 1997 through December 1997, the targeted sixth grade students will demonstrate an increase in motivation and interest in the science curriculum. In order to accomplish this objective, the following processes are necessary:

1. Utilize reading skills lessons that have application to the science curriculum.

2. Teach targeted reading skills within the context of the science textbook.

3. Develop a series of learning activities that enrich the science curriculum.

4. Develop a science-oriented student attitude survey.

Project Action Plan

Week/Date	Reading Class	Science Class
1 August 25-29, 1997	Skill: Using context to get word meaning	Activity: Administer student attitude survey
2 September 3-12, 1997	Skill: Noting correct sequence	Activity: Life of a star diagram
3 September 15-19, 1997	Skill: Continuation of noting correct sequence	Activity: Continuation of life of a star diagram
4 September 22-26, 1997	Skill: Noting important details Skill: SQ3R	Activity: No activity
5 September 29-October 3, 1997	Skill: Determining paragraph topics	Activity: Weight in Space
6 October 6-10, 1997	Skill: Reading diagrams and charts	Activity: Continuation of weight in space
7 October 13-17, 1997	Skill: Continuation of diagrams and charts	Activity: Quiz refraction/reflection
8 October 20-24, 1997	Skill: Determining main ideas	Activity: "I" Chart
9 October 27-October 31, 1997	Skill: Predicting outcomes	Activity: Grid for movement of stars
10 November 3-7, 1997	Skill: Drawing conclusions	Activity: Gumball machines
11 November 10-14, 1997	Skill: Recognizing cause-effect relationships	Activity: Bear from Science World
12 November 17-21, 1997	Skill: Reading time lines	Activity: Geologic Time in text

Methods of Assessment

In order to assess the effects of teaching reading strategies for transfer to the science curriculum, established science curricular pretests and posttests will be administered to all sixth grade science students. Reading curricular pretests and posttests of specific skills will be administered to the targeted sixth grade students. A science-oriented student attitude survey will be developed. Observational checklists to monitor students' science class participation will be designed.

As part of the assessment process, the research team will develop rubrics specific to the science learning activities that will be utilized to measure transfer of reading skills to the science curriculum. In an attempt to be as objective as possible when assessing these learning activities, the research team will hold scoring sessions. Every student's performance on an activity will be scored twice, each time by a separate reader. If there is a variance in interrater accuracy by a rubric score of more than two points on a five point scale, a third reader will be called to resolve the interrater discrepancy.

CHAPTER 4

PROJECT RESULTS

Historical Description of the Intervention

A group of sixth-grade teachers at one intermediate school expressed a common concern about student underachievement in science. These teachers formed a study team to conduct action research related to the perceived problem. Two months prior to project implementation, the team developed parameters of a study to be conducted at the beginning of the school year. The team examined student science test scores, observed pupil attitudes toward science, and compared student science academic grade with letter grades in other disciplines. Teachers formulated a plan of action to address student class participation, pupil motivation, student application of reading strategies to the science curriculum, and student science achievement. This research team utilized a variety of materials to measure project results. They grouped these materials into four categories: achievement, participation, transfer of reading skill knowledge, and motivation.

Prior to this investigation, the three reading teachers conducted reading classes in self-contained, autonomous settings. These teachers utilized a variety of instructional materials to teach reading, which included the district-adopted basal reading text, as well as trade books of different genres. Skill instruction was incidental to content being studied in other disciplines.

Before research project implementation, the two science teachers co-taught sixth grade science utilizing a variety of published materials. These materials included the district-adopted science textbook, worksheets, labs, and thematic units. Often a student project accompanied a unit of study.

The action research project objective was to improve sixth grade students' science achievement. The desired outcome was precipitated by teaching students specific reading skills and observing students' degree of application of those skills to daily science activities. To measure desired change, teachers utilized tests, quizzes, student questionnaires, student activities, observational checklists, and notational records.

During the summer prior to project implementation, the research team examined the science textbook, as well as the reading skills' sections of the basal reading series. Working collaboratively, team members identified specific reading skills inherent in both the reading series and science textbook. These skills included: using context to get word meaning; noting correct sequence; noting important details; determining paragraph topics; reading diagrams and charts; determining main ideas; predicting outcomes; drawing conclusions; recognizing cause-effect relationships; and reading time lines. As part of the action plan, reading teachers would focus classroom instruction on each specific reading skill as that skill was encountered in assigned science readings.

To measure students' application of skills learned in reading class to science, science teachers created original activities based on science textual matter (see Appendixes A - F). These activities were designed to foster students' application of each reading skill to a science lesson; teachers assigned an activity for 8 of the 10 reading skills addressed in this study. For example, during the week when "noting correct sequence" was apparent in the science text reading, reading teachers emphasized that skill in reading classes. Science teachers implemented the specifically-designed science activity that promoted application of "noting correct sequence" to the science lesson. The research team then measured students' application of the targeted reading skill to the science lesson.

In addition to identifying specific reading skills and developing science activities related to those targeted skills, members of the research team divided sixth grade students into three groups. The student composition of these groups was maintained throughout the first twelve weeks of the school year. Researchers labeled these groups Experimental 1, Experimental 2, and Control Group.

Action research began the second week of the school year. Two reading teachers taught students in Experimental 1. This group was comprised of 47 students who received 46 minutes of reading instruction daily. The two reading instructors taught and reinforced targeted reading skills. In addition to skill instruction, each teacher implemented oral readings of science text that had been assigned to students by the science teachers. During these readings, teachers made specific references to incidences in the science text where targeted reading skills were evidenced. To assess students' mastery of reading skills, instructors utilized commercially-prepared pretests and posttests.

Experimental 2 was composed of 21 students. One reading instructor provided students with 46 minutes of daily reading instruction. This instructor taught the targeted reading skills and, to reinforce instruction, employed reading activities. To assess students' mastery of reading skills, the teacher regularly administered commercially-prepared pretests and posttests. However, this instructor did not utilize readings from the science textbook with Experimental 2.

Reading teachers of Experimental 1 and Experimental 2 encouraged students to seek application of skills learned in reading class to content they were studying in other disciplines. They placed emphasis on transfer of understanding in science class.

Although the reading teachers taught targeted reading skills instruction to students in Experimental 1 and Experimental 2, Control Group (which consisted of 138 students) did not receive specific targeted reading skills instruction. Instructors of Control Group did not regularly administer reading skills pretests and posttests.

In addition to reading class, sixth grade students received 46 minutes of daily science instruction. Two science teachers co-taught science to five periods of sixth grade students. Three of the science classes were composed of approximately 45 students each, 23 of those students from an experimental group and 22 students from Control Group. The remaining 2 science classes were composed of approximately 45 students from Control Group. Science instructors did not vary instruction for students in Experimental 1, Experimental 2, and Control Group. They utilized lessons from the science textbook, as well as worksheets, labs and teacher-constructed activities. To assess students' science achievement, teachers examined students' grades for science chapter posttests, labs, projects, activities, and participation.

The two science teachers administered a pre- and post questionnaire to science students (see Appendix G). Results were used to examine students' attitudes toward science, and, specifically, the degree to which students enjoyed reading science text.

Within the science classroom, science teachers applied observational checklists to gauge student preparedness and motivation (see Appendix H). They assigned readings of science text as homework to students. These teachers offered reading guides to assist students with comprehension of text, pacing of lesson study, and attention to detail in lesson content (see Appendix I). Science teachers created and utilized activities designed to illustrate student transfer of skills learned in reading class to the science lesson. Rubrics were utilized to score students' science transfer activities (see Appendix J).

Science teachers collected data to monitor student classroom participation. These data were in the form of notations. Science teachers observed students and noted whether students were prepared for class, had completed homework, and had remained on task during science class.

On several occasions the research team deviated from the original action plan. Teachers of Experimental 1 were unable to maintain continuity of action plan delivery. On one occasion, one reading teacher was unable to keep pace with science textbook readings. In a second incidence, the other reading teacher accelerated a science textual reading by several pages.

Science teachers modified the observational checklist. Because there were approximately 45 students in each science class, the observer found it impossible to record students' oral responses. Therefore, students' written responses, in journal format, were collected at random and recorded.

In addition to modification of the observational checklist, the team extended instruction of one lesson plan. The lesson for Week 3 was continued 5 additional days.

Use of an interrater process as described in the original action plan was modified. The research team, faced with time constraints and a quantity of student-generated activities that required assessment, modified grading procedures as follows: Science teachers graded work and tests related to science class; reading teachers graded reading work and tests.

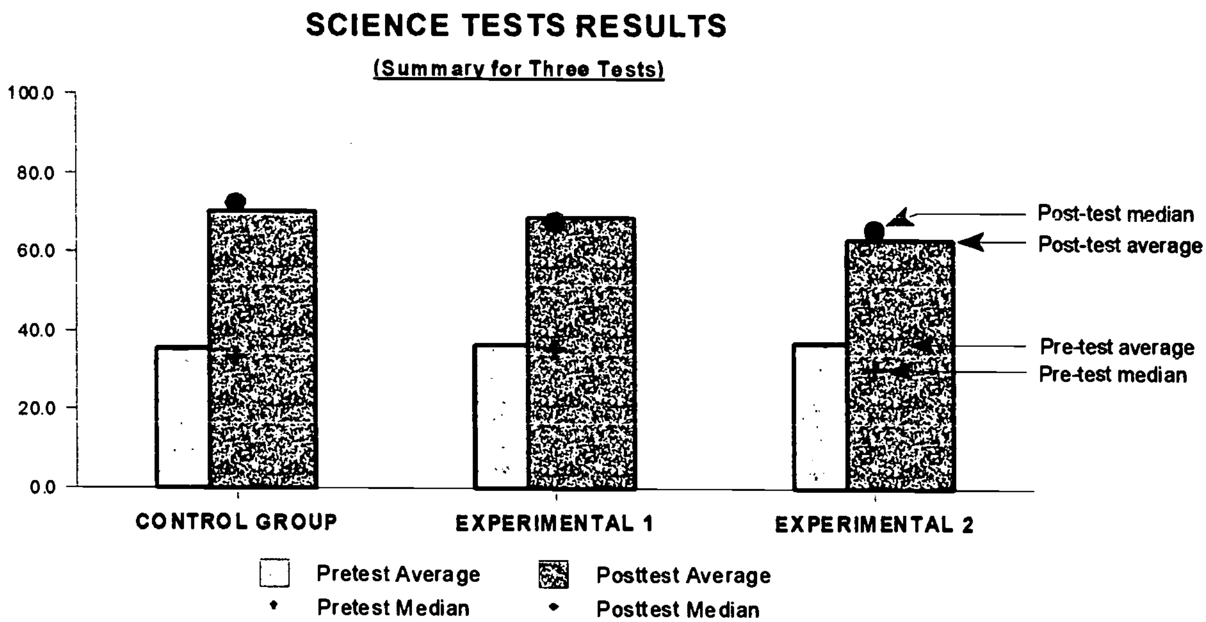
The study team made one further modification in the action plan. Science teachers did not utilize a science activity to measure students' transfer of understanding for the reading strategy "determining paragraph topics." They felt that, based on the science curriculum at that point in time, the proposed activity would have been too contrived. Therefore, teachers modified the assignment to fit science curriculum needs rather than those of the research project.

Presentation and Analysis of Results

Presented in Figure 3 is a summary of students' science achievement as measured by pretests and posttests. The posttest averages for students in Experimental 1, Experimental 2, and Control Group were relatively the same. Information from Figure 3 indicated that a comparable level of learning occurred for students in all groups.

A pre- and post questionnaire were administered to sixth grade science students. Noted was that, in most cases, students' responses shifted from positive replies on the pre-questionnaire to negative ones on the post questionnaire. Based upon the percentage of students who made dramatic negative shifts in response to questionnaire statement 7

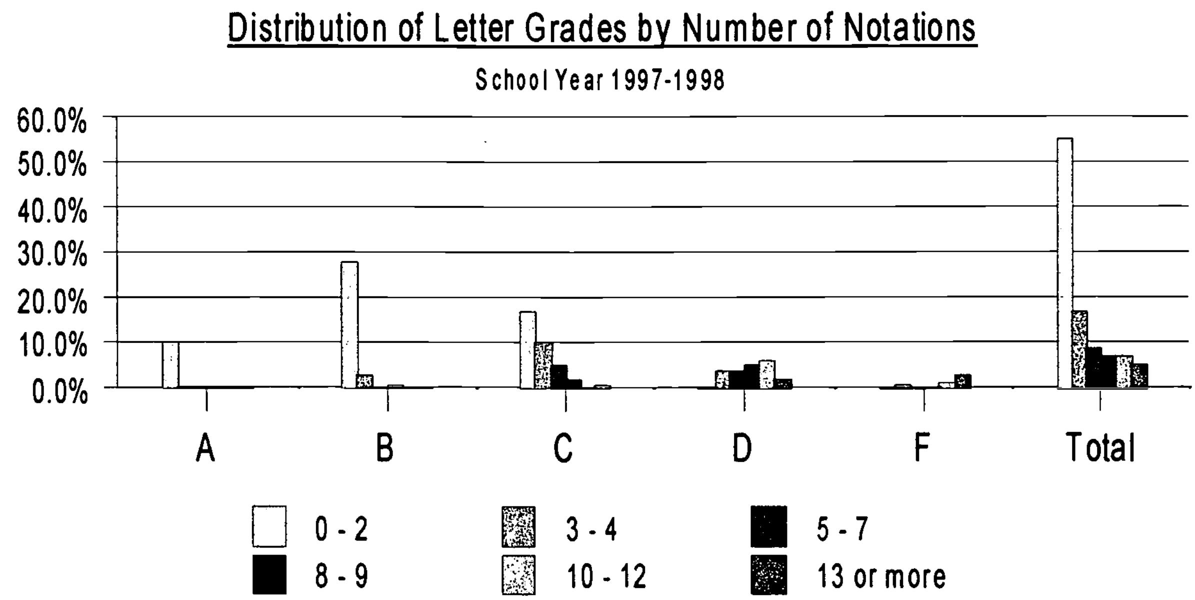
(I do my science homework.) and statement 12 (I come prepared to science class every day.), these statements are of concern to the research team. To determine reasons for such negativity merits further study.



Pretest Average	35.4	36.5	37.1
Posttest Average	70.1	68.5	63.0
Pretest Median	33.3	35.3	30.3
Posttest Median	72.3	67.7	65.7

Figure 3. Science test results summary for three tests.

As indicated in Figure 4, 81% of the students in science class earned 7 or fewer notations; of those students, 90% earned grades of A, B, or C. Further analysis indicated that 19% of the students in science class earned 8 or more notations; of those students, 86% earned grades of D or F. Apparent was a connection between number of notations earned by students and their academic performance.

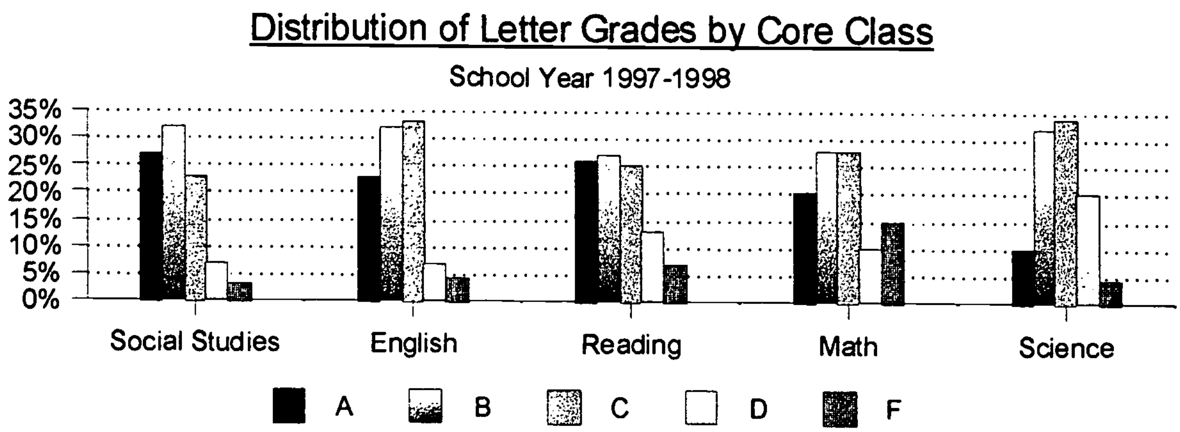


0 - 2	10.0%	28.0%	17.0%	0.0%	0.0%	55.0%
3 - 4	0.0%	3.0%	10.0%	4.0%	0.5%	17.0%
5 - 7	0.0%	0.0%	5.0%	4.0%	0.0%	9.0%
8 - 9	0.0%	0.5%	2.0%	5.0%	0.0%	7.0%
10 - 12	0.0%	0.0%	0.0%	6.0%	1.0%	7.0%
13 or more	0.0%	0.0%	0.5%	2.0%	3.0%	5.0%

Figure 4. Distribution of letter grades by number of notations (school year 1997-1998).

Figure 5 represents the percentage of letter grades earned by students in core classes of social studies, English, reading, math, and science. Evidenced in the data is that in science, math, and reading, more students earned grades of D or F than in social studies or English. Students in science earned fewer grades of A and more grades of D than in other subject areas. Recorded in science and math, which traditionally have non-narrative texts, were substantially a greater number of below-average grades than in the other disciplines.

Based on the results of Figure 4 and Figure 5, two conclusions were evident. A connection existed between academic grades and number of notations earned by students in science class. Students in science class earned fewer grades of A, and more grades of D, as compared to letter grades in other core subjects.



A		27%	23%	26%	20%	10%
B		32%	32%	27%	28%	32%
C		23%	33%	25%	28%	34%
D		7%	7%	13%	10%	20%
F		3%	4%	7%	15%	4%

Figure 5. Distribution of letter grades by core class for school year 1997-1998.

Science teachers utilized observational checklists to record students' class participation. Results are represented in Figure 6.

Students in Experimental 1 demonstrated a higher percentage of class participation than students in Experimental 2 or Control Group. Suggested in the results was that the students who read the science lesson in reading class were better prepared for science class discussions than other students.

To measure the transfer of reading skills' instruction to science, science instructors assessed students' performance on the teacher-designed science activities. If skill evidence was present, and if the student scored 70% or more on the activity, science teachers assessed that student skill transfer had occurred. Performance results for

"Noting Correct Sequence" can be seen in Figure 7.

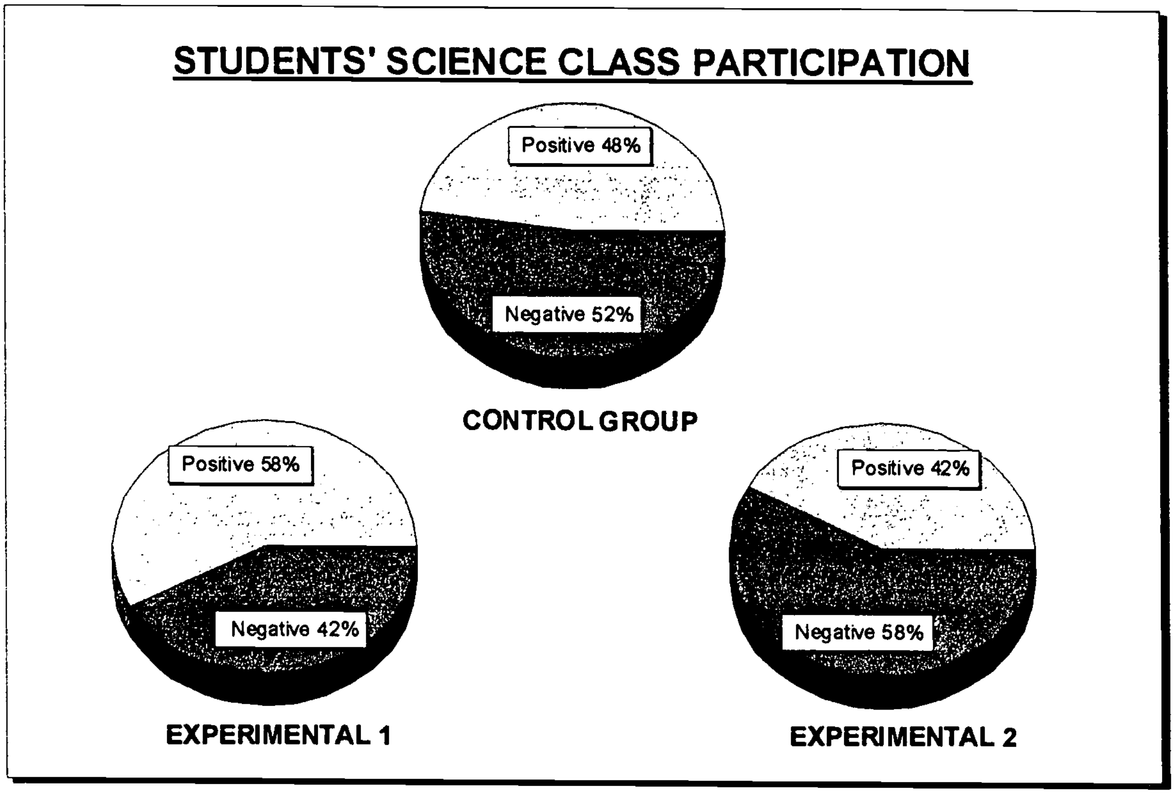
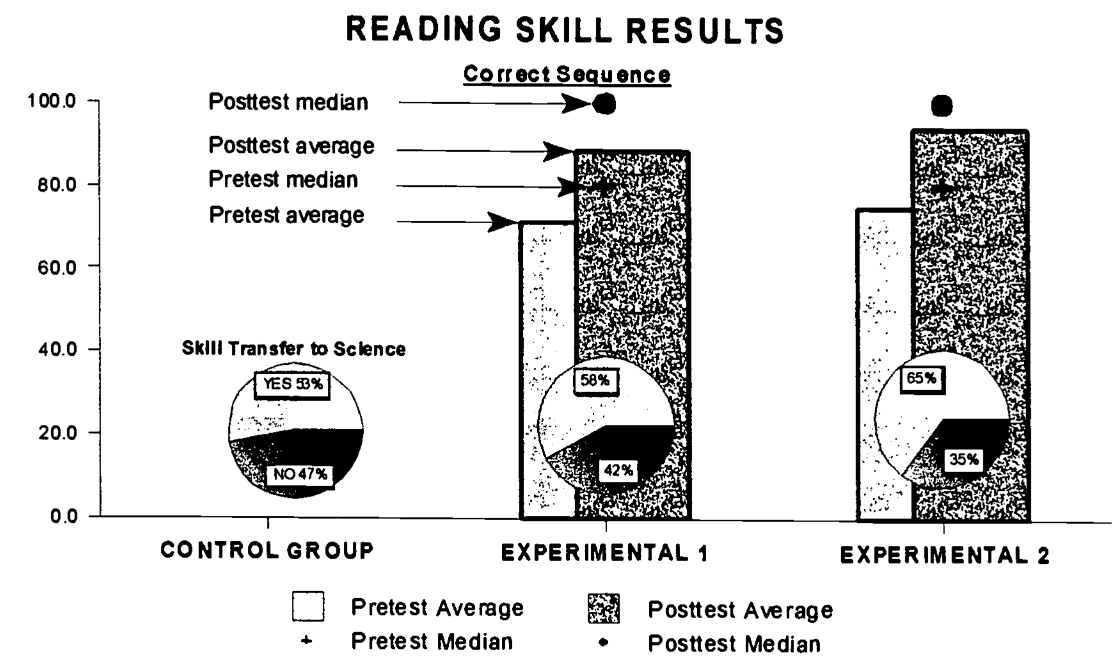


Figure 6. Students' science class participation.

Evidenced was that students in both Experimental 1 and Experimental 2 mastered the reading skill. Although science students, in general, demonstrated success in the transfer activity, the degree of transfer for students in Experimental 1 and Experimental 2 exceeded that of Control Group.

Similar results occurred for "Drawing Conclusions" (see Figure 8). Mastery of skill occurred for students in Experimental 1 and Experimental 2. Skill transfer was apparent for a high percentage of students from the three groups.

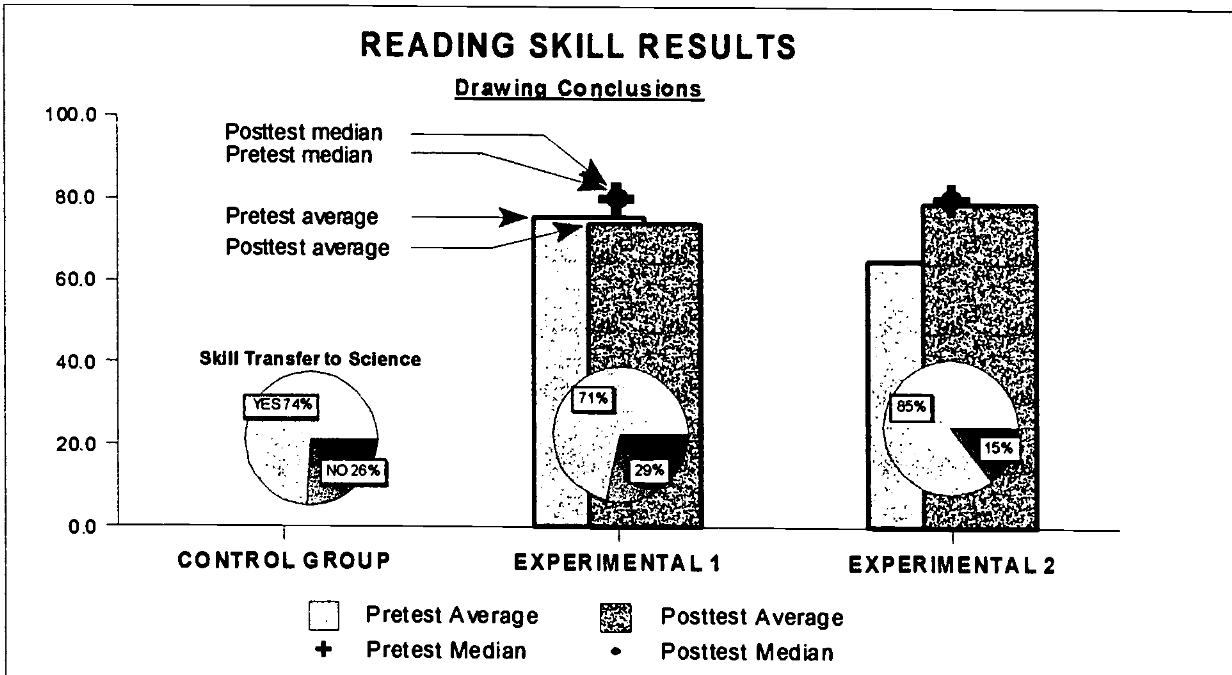
Figure 9 represents reading skills' results and percentages of skills' transfer to science. The percentage of students who demonstrated successful application of reading skills to science activities varied by group. An analysis of variance (ANOVA) was used to establish whether or not a significant (nonchance) difference existed among the sample means. No group demonstrated significant transfer over any other group. Results indicated that teaching reading skills in context of the science text had little bearing on students' transfer of skills into science.



Pretest Average		71.5	75.0
Posttest Average		88.3	93.7
Pretest Median		80.0	80.0
Posttest Median		100.0	100.0

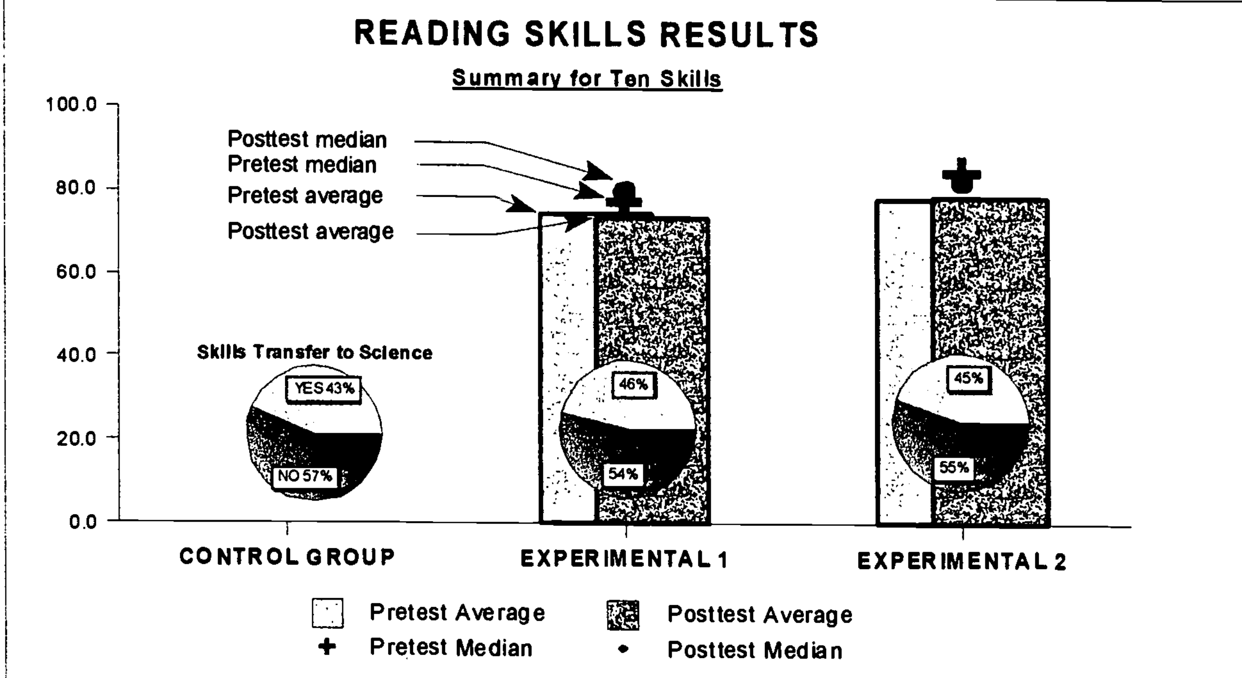
Figure 7. Reading skill results for Noting Correct Sequence.

After concluding the research project, reading teachers of Experimental 1 and Experimental 2 asked students to respond to the following question: What are some of the things we did in reading class that helped you be successful in science class? Teachers grouped students' answers into 10 categories. Students in the experimental groups generated two responses with more frequency than others. Fifty percent of the students said that additional explanation of science text in reading class was helpful in science class; 62% stated they felt the additional study of science in reading class had a positive influence on their science test scores. Noted, however, was that students' science test scores did not reflect students' positive perceptions.



Pretest Average		75.1	65.0
Posttest Average		73.7	79.0
Pretest Median		80.0	80.0
Posttest Median		80.0	80.0

Figure 8. Reading skill results for Drawing Conclusions.



Pretest Average		74.1	77.8
Posttest Average		73.4	78.5
Pretest Median		77.2	84.1
Posttest Median		79.8	82.3

Figure 9. Reading skill results summary for ten skills.

Conclusions and Recommendations

Although the study team detected few apparent increases in student achievement, participation, or application of reading skills to science among students in the experimental groups as compared to students in Control Group, students in Experimental 1 and Experimental 2 stated they felt that studying science in both the reading and science classrooms was helpful. Student responses to the post-experiment question supported those claims.

One recommendation for future plan implementation would be to seek alternative reading skills pretests and posttests. Numerous students demonstrated lower performance on a reading skill posttest than on the pretest of that same skill. Reading teachers noted a disparity in degree of difficulty between a skill pretest and posttest. Occasions occurred whereby questions on a specific pretest elicited comprehension-level student responses; however, posttest questions required students to synthesize knowledge, a skill that had not been taught.

For those students whose reading abilities were incompatible with the science text, the study team, in addition to the science textbook, would consider use of supplemental texts and trade books, as suggested by Baer and Nourie (1993). Using peers to rewrite textual material might also be helpful to students unable to read grade-level texts. If students had found it easier to read and comprehend the science lessons, they might have demonstrated a higher level of performance on daily activities as well as science tests.

Concerned about students' lack of ability to predict vocabulary meanings, team members suggest incorporation of Possible Sentences, a strategy designed by Moore and Moore. Asking students to predict word meanings by writing sentences that utilize words with which the students are familiar, in conjunction with unfamiliar words extracted from the science text, would be beneficial for students' vocabulary development.

An additional recommendation would be to revise the student questionnaire. The original questionnaire did not identify students by name or identification number. Use of a method of identification would have permitted team members to examine, by group, students' reading skill achievement, degree of skill transfer to science activity, and attitude toward science.

A further refinement would be to begin project implementation later in the school year, as opposed to the second week of school. The research team concluded that, by beginning the study early in the school year, results of the student questionnaires were adversely affected. Students did not have time to form an opinion of the science text. They had not become accustomed to a daily science class, as opposed to science class in elementary school which met 2 or 3 times weekly. They were unfamiliar with science teachers' expectations. Students had not assessed their own abilities to be successful in sixth grade science.

Important to note is that science teachers assessed students' late work, or work not turned in, as a zero score (negative). The reason for this was to maintain integrity of class rules during the action research project. Therefore, when examining percentages of students who transferred the reading skills to science activities, worthy of consideration is that there may have been students who mastered application but did not submit the assignment for assessment. Data would not reflect that mastery. Including those zeros when averaging students' scores may have come at the expense of obtaining a higher percentage of skills' transfer results.

To increase the number of students who might achieve transfer of reading skills to the science activities, the study team would consider implementing tenets of a negotiated curriculum, as suggested by Davenport and Jaeger (1995). Teachers could involve students in setting goals and formulating the action plan. By involving them in the planning process, students would more likely feel a sense of ownership to their learning and be more adept at assessing their progress.

A further recommendation would be for reading teachers to teach and monitor fewer than 10 skills in 12 weeks. With implementation of fewer skills, science teachers and reading instructors could provide students with additional skills' practice, thereby increasing the opportunities to achieve mastery. Providing additional time for mastery of each skill might have prompted a greater degree of science activity transfer.

Although a similar number of students in Experimental 1, Experimental 2, and Control Group demonstrated transfer of reading skills to science activities, transfer results may have been affected by the fact that science teachers designed the science activities with no prior knowledge of how reading teachers taught the reading skills. Team members suggest that a collaborative effort between the reading and science instructors to design transfer activities is worthy of consideration.

In addition to a collaboration between science and reading teachers when creating transfer activities, the research team promotes incorporation of a strategy designed by Simmers, Wolpow, Farrell, and Tonjes (1991). There could be an effort by all faculty members to teach specific skills to students on designated days. Encouraging students to apply the skill learned in reading class to subject matter in all content classes throughout the school day might result in a higher percentage of students demonstrating transfer of understanding.

Researchers are somewhat concerned that results of the study appear to be counter-intuitive, i.e. even though students in the experimental groups received additional help by the reading teachers, their scores did not reflect substantial increases in science knowledge or skill transfer when compared to students' scores from Control Group.

Additional study is needed to determine whether students might have experienced greater success if reading skills had been taught in the science classroom by the content teachers. Educating students in reading skills that promote comprehension of nonfiction text within content area classrooms might have facilitated students' transfer of understanding and induced all teachers to become teachers of reading.

Professionals in the field of education must continue to address student underachievement in science.

> For both the students who will study and use science in their careers, and for all students, who need to be well-informed citizens, the broad goal of a school science program should be to foster understanding, interest, and appreciation of the world in which we live. Along with building a knowledge base, science education should encourage students' natural curiosity, develop procedural skills for investigating and problem-solving, consider the possibilities and limits of science and technology in human affairs, and build an understanding of the nature of science and technology as fields of inquiry themselves (Zemelman, Daniels, & Hyde, 1993, p.94).

Teachers must utilize instructional delivery that nourishes within students a sense of accomplishment and personal satisfaction. Instructors must help students perceive connections between schoolwork and life experiences. Only through persistent efforts by dedicated educators seeking effective strategies to make science learning meaningful can solutions be realized.

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APPENDICES

☐ - hydrogen

Life of a Star:

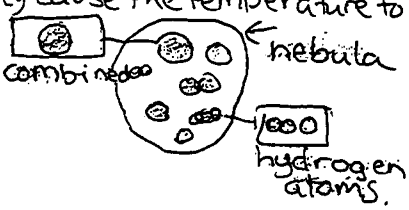
☐ - dust

Birth-

1. Gravity pulls dust and hydrogen close together in the nebula.

2. Slowly the cloud starts to look like a ball, and as the hydrogen & dust are pulled closer together, it starts to shrink.

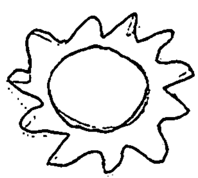
3. Hydrogen atoms are compressed, and they cause the temperature to rise.



4. The atoms grow higher and higher in temperature that they become many million degrees and form new element. They make amazing amounts of energy.

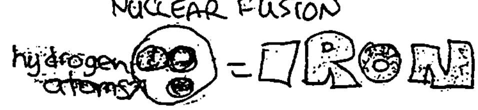
OO = O a new element = Energy

5. Energy is strong enough to push the surface of the ball out and as strong as the gravity pulling in. The ball stops shrinking. Energy realeased as light makes it glow. A star is born.

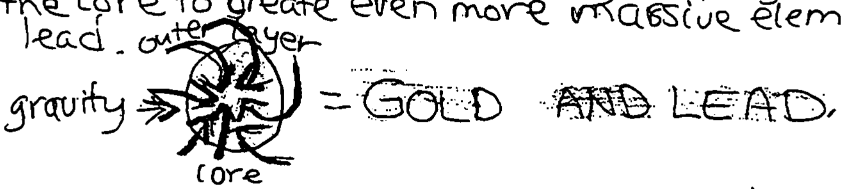


Death:

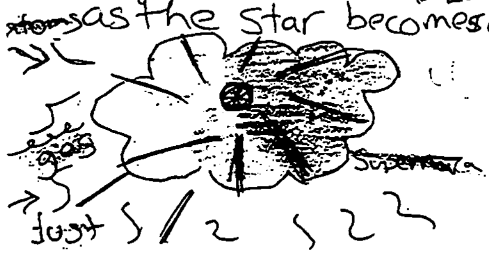
1. Bigger Stars still swell after and while being red giants. Nuclear Fusion now produces elements such as iron.



2. Fuel runs down and the star cools down. When cooled, the outer layer are pulled to the middle by gravity. One afer another the outer atoms smash into the core, heating it up again. The heat allows the core to greate even more massive elements such as gold and lead.



3. Meanwhile, the core becomes very, very hot, until an explosion occurs. Loads of atoms are blasted in all directions as the star becomes a SUPERNOVA. It also releases gas and dust.



Finally, the gas and dust from the Supernova, beome parts of other stars, and become other nebulas and the star life cycle continues.

Appendix B

[redacted]

Beautiful!!

Gravity is an invisible force that pulls on things. The pull of earth's gravity is what gives us weight. The size, mass, and density of a planet or moon determines its gravitational pull. We consider the surface gravity of the earth to be 1. Look at the chart of surface gravities of the moon and other planets and predict what you think your weight would be on each of them.

C = 5
P = 5

My weight on earth is ______.

Predict in Pen on others

	Surface Gravity	Predicted Weight	Actual Weight	Difference
Moon	.16	30 lb.	14 lb	16
Mercury	.39	50 lb	35 lb	15
Venus	.91	82 lb.	82	0
Mars	.38	48 lb	34	14
Jupiter	2.60	197 lb	234	37
Saturn	1.07	100 lb	96	4 lb
Uranus	.90	80 lb	81	1
Neptune	1.15	110 lb	104	6 lb
Pluto	.05	15 lb	5	10 lb

+1

On which planet would you weigh the least? Pluto +1

On which planets would you weigh more than on the earth? Jupiter, Saturn, + Neptune +1

On which planets would you weigh nearly the same as on earth? Saturn, Venus +1

6/6

OUT OF THIS WORLD

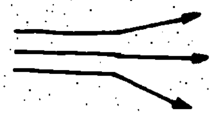
Appendix C

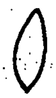
Quiz - Refraction/Reflection
Science - 6th
Englund/Mielenhausen

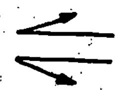
Name
Period

1-5 Match the light source to the mirror or lens.

1. 

A. 

2. 

B. 

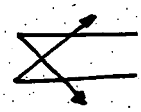
3. 

C. 

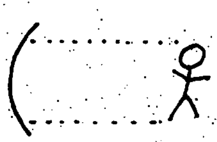
4. 

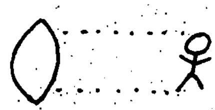
D. 

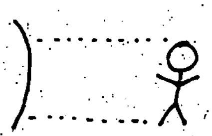
5. 

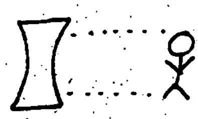
F. 

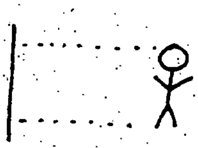
6-10 How would the stick figure appear through the lens or on the mirror; larger, smaller, or the same?

6. 

9. 

7. 

10. 

8. 

Lesson 2.3

Main Topic: Invisible Waves

√+

THE "I"

Pg. A40 - A43

Topic: Gamma rays, X rays, Invisible

The main idea is: How you can learn from waves though you don't see them

Details

Scientists made a detector that can show how much invisible radiation stars give

Gamma rays can be used to preserve food and get rid of tumors and bacteria

X rays and UV waves can help or they can be harmful.

Different types of images

MAIN IDEA QUESTIONS

How do they get the detectors to work?

THE "I"

Pg. A44-A45

Topic: Infrared and Radio waves

The main idea is: To tell us how Infrared and Radio waves can help scientists learn about stars.

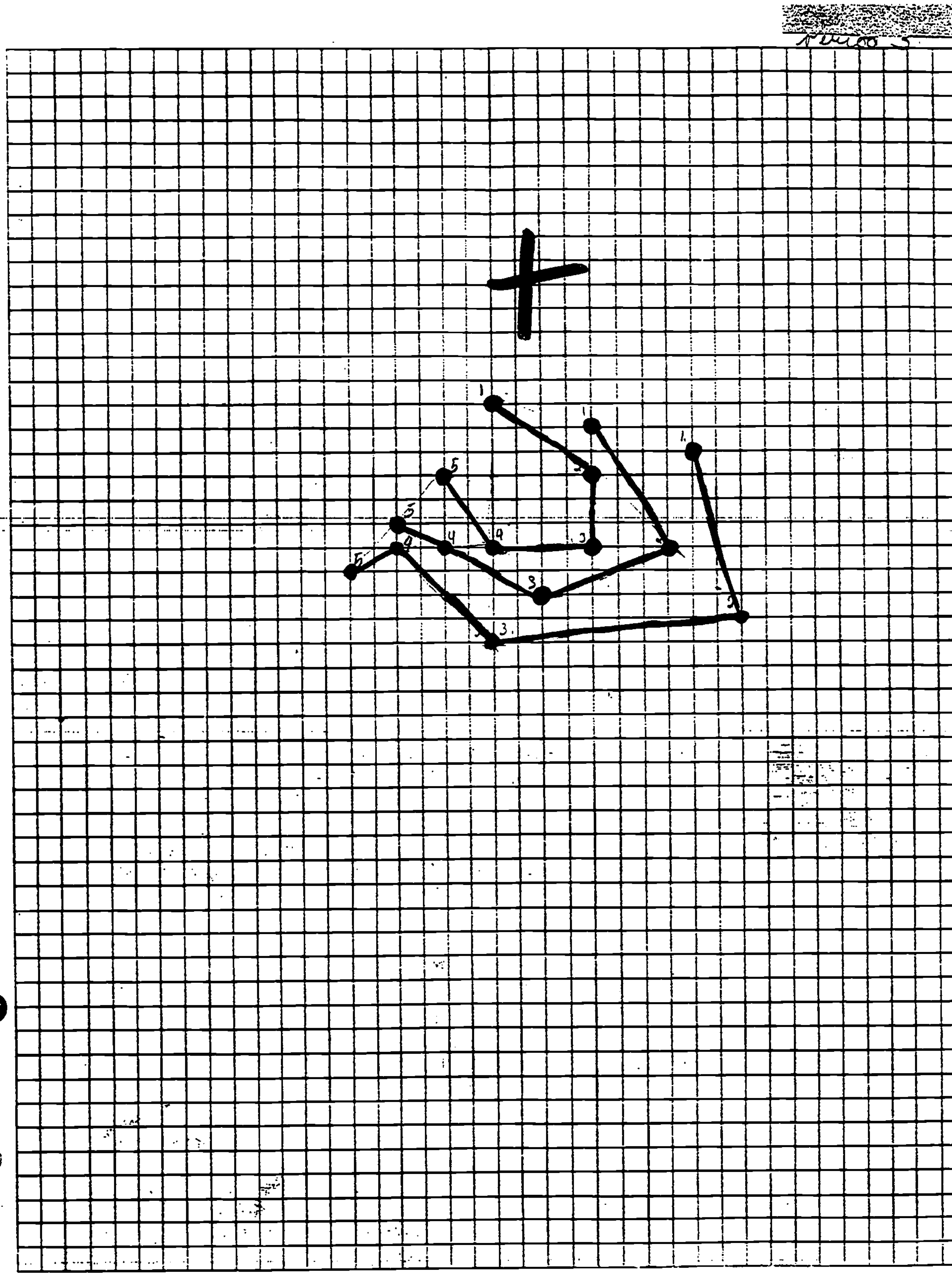
Infrared waves: They help scientists learn about objects that don't give much light

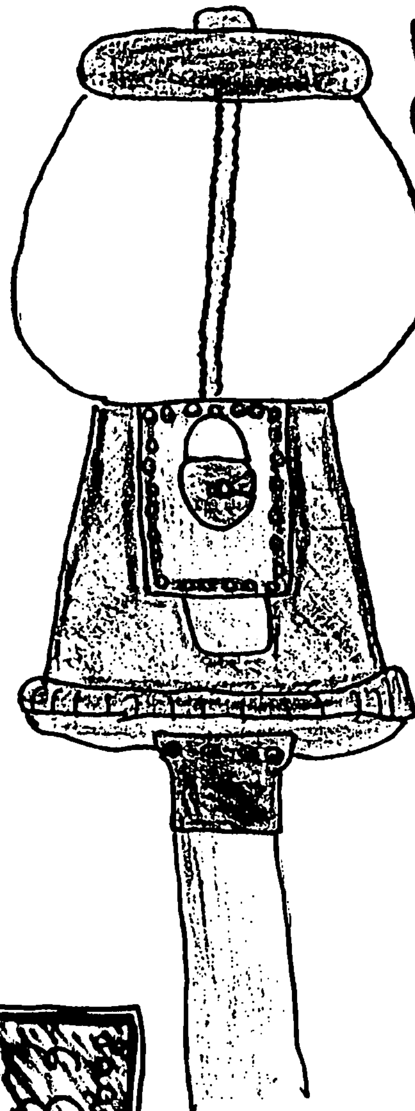
Radio waves: it lets waves travel through different types of distances this helps scientists study faraway stars

MAIN IDEA QUESTIONS

Are infrared and radio waves harmful or helpful to us in any way?

Appendix E

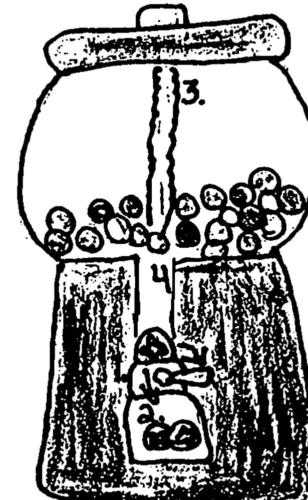




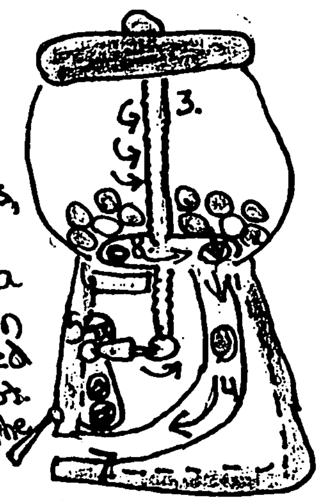
What Goes On In This Machine?

10/28/96

I think that.........



1. Money is dropped in. Crank is turned
2. Money goes in chamber in machine
3. Screw
4. Chute for gum



5. As the crank turns, the screw moves
6. The screw turns a plate with a hole in it. The hole is blocked so gum won't come out. As it turns above the chute, the hole is lined up with the chute
7. The gum drops through the hole, down the chute, and into the person's hand.
8. disk/plate

[redacted] Per 5 Science

Appendix G

Questionnaire

Please answer the following statements as best as you can. The following represent what each letter stands for.
N = Never R = Rarely S = Sometimes O = Often A = Always

1. I enjoy reading a science textbook.
N R S O A

2. Given the choice between reading language arts, social studies, math and science, I prefer reading a science textbook.
N R S O A

3. Science is my favorite subject.
N R S O A

4. I learn best by hearing the science textbook read out loud.
N R S O A

5. I learn best by reading the science textbook by myself.
N R S O A

6. I understand what I read in the science textbook.
N R S O A

7. I do my science homework.
N R S O A

8. I feel that I am on task in science class.
N R S O A

9. Books that I read are science related.
N R S O A

10. I prefer to read non-fiction materials.
N R S O A

11. I am successful in science.
N R S O A

12. I come prepared to science class everyday or on days I had science.
N R S O A

13. I use the skills I learn in reading class to help me understand the science textbook.
N R S O A

Journal Entry

1. What is the electromagnetic spectrum?

2. Write down all you know about light waves?

3. What information do scientists get from starlight?

Appendix I

MODULE A CHAPTER 3 HISTORY OF ASTRONOMY
LESSON 3.1 GUIDING STARS

NAME:
PERIOD:

LOCATION	SPEED	MISSION: READ THE FOLLOWING QUESTIONS CAREFULLY BEFORE YOU BEGIN READING.
► How did people learn from stars long ago? p A53 paragraphs 1 & 2	START / READ QUICKLY	Q. How did people who lived long ago study the stars?
MYTH MAKERS — page A53 paragraphs 1–3	READ, THINK, ENJOY	Q. Why did early cultures create similar star maps? Q. Briefly explain the myth of Callisto.
page A53 paragraph 4	SLOW DOWN IMPORTANT!	Q. Why were myths important to ancient people?
COMPASSES, CALENDARS, AND CLOCKS — page A54 paragraphs 1-2	SLOW DOWN, READ CAREFULLY, TAKE NOTES	Q. FILL IN THE GRAPHIC ORGANIZER. (EARLY USES OF STARS) Q. HOW DID ANCIENT CULTURES USE THE MYTH OF CALLISTO? Q. WHY DO SAILORS AND TRAVELERS USE THE NORTH STAR AS A GUIDING STAR?
page A55 paragraph 1	READ QUICKLY	Q. WHY WAS IT IMPORTANT FOR ANCIENT CULTURES TO BE ABLE TO READ THE STARS AND NOTICE THE CHANGE OF SEASONS?
page A55 paragraph 2	SLOW DOWN, READ CAREFULLY, TAKE NOTES / STOP	Q. BRIEFLY EXPLAIN HOW THE FOLLOWING ANCIENT PEOPLE USED THE STARS AND PLANETS. 1. BRONZE AGE PEOPLE IN ENGLAND – 2. NATIVE AMERICANS IN PRESENT DAY WYOMING – 3. MAYAS FROM ANCIENT CENTRAL AMERICA –

Appendix J

5 **Outstanding performance**
- Complete understanding of important concepts or ideas
- Demonstrates mastery of strategies and skills
- Goes above and beyond requirements

4 **Solid performance**
- Demonstrates very good understanding of important concepts or ideas
- Demonstrates notable achievement of strategies and skills
- Presentation is clean, neat, and easily understandable

3 **Adequate performance**
- Displays an adequate understanding of important concepts or ideas
- Demonstrates important strategies and skills without significant error
- Presentation is complete but lacks neatness

2 **Less than adequate performance**
- Displays an incomplete understanding of important concepts or ideas
- Makes significant errors when carrying out important strategies and skills
- Presentation is incomplete and lacks neatness

1 **Poor performance**
- Demonstrates serious misconceptions about concepts and ideas
- Makes critical errors when carrying out strategies and skills
- Presentation is incomplete, lacks neatness, and is difficult to understand

0 **No attempt**

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