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A Study of the Effects of Constructivist Based vs. Traditional Direct Instruction on 8th Grade Science Comprehension

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ABSTRACT

A STUDY OF THE EFFECTS OF CONSTRUCTIVIST BASED VS. TRADITIONAL DIRECT INSTRUCTION ON 8TH GRADE SCIENCE COMPREHENSION

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Studies conducted nationwide over the past several decades point consistently to the evidence that American school children lag behind several other countries in science scores. Problems arise from this dilemma, including the question of the ability of our youngsters to compete nationally and globally in the sciences as adults. Current research in this area of scores currently studies mostly mathematics. The few studies conducted concerning science mainly highlight students in other countries and neglects minorities and females regarding outcomes.

By contrast, this study investigated the effects of teacher types (also defined as teaching styles or classroom orientation) on student outcomes on two measures; the standardized Standards of Learning 8th grade science test for the state of Virginia, and the Higher-Order Skills test (Berube, 2001), which was a researcher-constructed comprehension measurement. Minority and gender interactions were analyzed as well. Teacher type was designated by using the Constructivist Learning Environment Survey (Taylor & Fraser, 1991). Participants included students from five large urban middle schools and thirteen middle school science teachers. Scores from the two measures were used to determine differences in student outcomes as they pertained to teacher type, gender and ethnicity.

Analysis indicated that students who were taught by teachers with more traditional and mixed teaching styles performed better on the Higher-Order Skills comprehension measurement, while teachers with constructivist teaching styles actually had the lowest scoring students. Also, the interaction of ethnicity and teacher type was significant, indicating that Higher-Order Skills scores were influenced by that interaction, with Caucasians scoring the highest when taught by teachers with mixed teaching styles.

Such findings could profit school administrators considering the interaction of student achievement and teaching styles on high-stakes testing environments. Suggestions are made for future studies concerning females and minorities in these same environments.

Dedication

This dissertation is dedicated to my children; Donnie, Cristin, Nick and John. Always work hard for your dreams.

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CHAPTER 1

INTRODUCTION

There is concern in classrooms throughout the nation over how science should be taught. Schoolchildren of all ages are failing science in record numbers and becoming intellectually disenfranchised with science by middle school. A cause for alarm in the decline in science achievement was signaled by the U.S. Department of Education's Report, "A Nation At Risk, The Imperative For Educational Reform", published in 1983. The report stated "that seventeen year olds as measured by national assessments of science in 1973, 1977, and 1979" declined in science scores. Moreover, science students did not fare well in comparison with other industrialized nations. The report quoted a former director of the National Science Foundation that there is a growing chasm between a small scientific and technological elite and citizenry ill-informed, and largely uninformed, on issues with a science component. This report also claimed that student deficiencies in higher-level thinking are indicative of a major weakness in the American educational system and that emphasis is placed on facts and low-level skills (A Nation At Risk, 1983).

Although most students in the United States do not major in science, general science understanding still needs to improve in order for U.S. students to compete with other countries in science achievement. According to the manner in which science currently is taught, students need detailed mathematical knowledge in order to sign up for some courses in high school. In an argument put forth in the article "Understanding Science", in the British publication *The Economist*, an anonymous author states that since many

scientific facts are provisional, disputed, arcane or frankly intelligible to anyone without higher mathematics, a better course than trying to compile some list of facts is to teach methods of science without drowning people in detail(Anonymous, 1997).

Reform movements in education are not new and they are always a reflection of the larger society. The Soviet satellite Sputnik, launched on October 4th, 1957, marked a huge turning point in the American space program. When Sputnik sent the first signals ever from space, the "space race" had begun. The space race grew out of the Cold War between the United States and the Soviet Union. For 50 years the two superpowers struggled for global supremacy. Space was a crucial arena for this battle.

Americans became worried about the Soviet accomplishments and soon the development of space technology became a national priority. As a result, President Eisenhower was pressured to create the National Air and Space Administration (NASA). The Soviet Sputnik launch also forced Congress to allocate additional money into science and math education in the hope of making America's youth more competitive with their Soviet counterparts.

A second result of the Space Race was a formulation of a committee to address prevalent questions and problems in science education. In September of 1959, thirty-five educators, scientists and scholars gathered at a conference at Woods Hole on Cape Cod to discuss how science education might be improved in America's schools. The ten-day meeting was called by the National Academy of Sciences which had been examining through its Education Committee, the long-range problem of improving access to scientific knowledge in America. The intention was to examine the fundamental processes involved in imparting to students a sense of the methods and foundations of

science (Bruner, 1960). This was the first time psychologists had been brought together with scientists to discuss problems involved with teaching various disciplines. The major topic of discussion was how children learn science.

"A Nation at Risk" also triggered a national educational reform movement. In the early 1980's, a "back to basics" stance among mostly Republicans, jump-started the "excellence reform" movement backed by Ronald Reagan, which emphasized raising National standards. Since the publication of "A Nation At Risk", a number of reform efforts in science education have resulted in the improvement in the average scores in science. President George Bush declared an agenda for reform entitled *Goals 2000* with six major objectives whereby the United States would be first in international comparisons. Science education was one of these. President Bill Clinton continued the agenda, adding new goals such as graduation rates and literacy (U.S. Department of Education, "Goals 2000: Educate America Act", enacted January 25, 1994).

This reform movement triggered a general rise in scores, however one exception to the rise in student achievement has been with African-American students, whose scores did not show a significant rise in the few years after the report. According to a Federal study, "between 1986 and 1996, there were no further statistically significant changes in the black-white performance gap in science" (The Condition of Education, 1999). Research also shows that there is a marked difference in the achievement in science between white and minority students, especially African-Americans. According to Oakes, disproportionate percentages of poor and minority students, principally African-Americans, are using curricula designed for low-ability or non-college bound students. Furthermore, in general, low-income and minority students usually have less contact with

the best science and mathematics teachers (Oakes et al., 1990). Also, little recent data have been published that permit an examination of achievement by sex, ethnicity or race (How Schools Shortchange Girls: The AAUW Report, p. 55).

Science achievement of United States students *still* ranks significantly below other industrialized nations. Secondary school science students rank 19th among 21 industrialized nations in science achievement. Eighth graders scored 10th out of 26 countries in science. Fourth graders scored 2nd out of 10 (The Condition of Education, 1999). The problem of American students scoring below other countries in science is growing more acute with the national drive for mastery of standardized objectives. In Virginia, accreditation hangs in the balance if schools do not pass the Standards of Learning (SOL) tests. In 1995, the Board of Education of the Commonwealth of Virginia took an important step to raise the standards for students in public schools by adopting new standards of learning in the areas of mathematics, English, history and social science, science and computer technology. In 1998, standards of learning assessments were written. They were composed of multiple-choice items and writing prompts (for English) and were designed to test all of the content areas of all the standards of learning (Virginia SOL Technical Report, p.v, 1). However, pressure also was put on administrators and teachers for their students to pass the tests. Teachers are threatened with losing their jobs if their classes do not pass the tests. However, even if the students pass the tests, it does not prove comprehension. Scores on multiple-choice tests reflect whether a student selected the correct answer, but do not reflect the problem-solving strategies and conceptual understanding used to arrive at the answer (Bol et al, 1998).

The current frenzy for high standardized test scores is a direct result of the national excellence reform movement. While the effort is well-intentioned, one may question if top-down managerial techniques involve grading our teachers and schools with report cards to be published in newspapers, improves American schooling (Gregoire & Algina, 2000).

What some in education fail to realize is that high scores on standardized multiple-choice tests do not necessarily indicate conceptual understanding of scientific subject matter (Ravitch, 2000). Higher standards must be measured in some way, and multiple choice tests became the logical answer. (However, these tests address quantitative issues rather than qualitative concerns). These objective tests also only measure the lowest levels of learning, such as knowledge and retention, neglecting higher levels of thinking such as synthesis and evaluation (Bloom,1956). This is not to say that standardized tests are all bad or unnecessary, only that one cannot look at the results of a standardized test and derive from its score that the student understands the subject matter, only that they chose the correct answer. Bol & Strage state that many tests focus on the lower levels of learning, neglecting the higher levels (Bol & Strage, 1998).

According to Applefield et al (2001), the more traditional teaching techniques employ a bottom-up strategy that isolates the basic skills, teaching them separately and building these before taking on higher order tasks. Constructivism does the opposite, and instead of structuring the elements of any topic to be learned, real learning proceeds from the natural need to form understanding and necessary skills required for completion of real problem-solving tasks. Also, results of standardized test scores show that less successful students are not making progress in mastering basic content in science, and there is

evidence that they are falling behind their classmates in other subjects (Applefield et al, 2001).

In effect, the learning environment should represent as closely as possible, the natural complexity of the real world and avoid oversimplification of instruction. It should also support knowledge construction through collaboration and social interaction (Jonassen, 1991).

Gardner (1999), in his book The Disciplined Mind, writes that students should be taught fewer concepts in school, but at greater depth. His main argument is toward teaching for understanding. Gardner states: "Let me introduce my alternative educational vision-one firmly centered on understanding. An individual understands a concept, skill, theory or domain of knowledge to the extent that he or she can apply it appropriately in a new situation. An individual with a keen memory merely remembers the information and has not a clue about how to use it appropriately in an unfamiliar circumstance" (p. 118-119).

Many lament the problem that school curricula contains so much material with so little time to cover it, placing great emphasis on coverage of breadth, not deapth. When emphasis is placed on recall, learning is temporary and material is forgotten. Americans tend to value quantity rather than quality of learning. The more important learning outcome for all age groups involves learning in depth, not breadth (Applefield et al, 2001).

Gardner defines an individual who understands what he or she is taught as one who, while possessing relevant understanding, can employ appropriate concepts while dismissing irrelevant ones (Gardner,1999). Gardner also poses that observers may be

impressed by how much information the child seems to be learning, if one weighs only the mastery of individual numbers, facts, definitions, etc. He also implies that of all the disciplines, the telltale weakness is found among physics students in colleges and universities, indicating that the pattern of teaching for factual memorization continues throughout their educational career. The students perform credibly in classroom exercises and end-of-term tests. But outside class, when they are asked to explain relatively simple phenomena, such as the forces operating on a tossed coin, a significant proportion of students (often more than half) failed to give the appropriate explanation. Physics students also tend to give the same kind of answers as peers and younger children who have never studied mechanical physics. They do not understand concepts, but can pass a standardized test because they have memorized the information and are practiced at multiple-choice tests (Gardner, 1999).

Content builds on itself during schooling. Research suggests that by high school, if basic scientific concepts are not learned, students will not proceed onto higher-level science courses. Girls especially fall into this category. Historically, girls have received inadequate attention and support for scientific interests and pursuits. Research shows that they receive less attention in science than boys do, and the attention is to be of lesser quality and pro forma. During elementary school, girls and boys perform equally well, however by high school, there are almost no girls left in advanced placement science classes (AAUW, 1992).

Albert, a high school science teacher, is disheartened from the fact that his students "parroted back biochemical terms but failed to grasp the concepts…(and) were not really learning anything". Albert blames standardized multiple choice tests, claiming that they

"emphasize memorization and word association over conceptual knowledge...(and that) these tests are poor judges of students' abilities." The result, according to Albert, is a generation of students turned off by science and bereft of the analytical skills needed to be successful science students (Carey, 1997, pp.66-67).

Realizing that most U.S. students will not be on the science college track, teachers still have an obligation to help them to be knowledgeable in science, and not just at the fact-based memorization level, but for conceptual understanding. The traditional way to teach science, based almost completely on direct instruction lessons, has left our students scientifically illiterate and conceptually ignorant. Teaching science using more student-centered techniques would close the gap between those students who can memorize terms and those who understand the concepts behind the terms (Carey, 1997).

Research on Classroom Environment

Research studies suggest that historically, educational environments have been embedded within psychological frameworks, namely behavioral psychology which has focused on changes in behavior. This trend continued until the 1960's, at which time cognitive psychology was gaining attention as the foundation for education (Fraser, 1986). Emphasis has been placed on students' perspectives and success-driven models of instruction. This section will include learning pedagogies and their respective contributions to classroom environment; including constructivism and traditional classroom environments.

Constructivism is a learning pedagogy that is student-centered and based on a learning theory that focuses on how students develop understandings. Constructivism is also the notion that children build knowledge from their own experiences (Richardson,

1999). Constructivist classroom environments foster both experience and social interaction in a student's development of knowledge. Constructivist teachers believe that experience and social interaction affect the cognitive processes of students. Instead of focusing on the details of the lesson, constructivist teachers focus more on whether or not conceptual learning and development is taking place (Baker & Piburn, 1997).

Classroom environments of exemplary teachers have been studied by Tobin and Fraser (1991). Qualitative data were gathered by direct observation of eight lessons by participants. The findings of the study revealed several assertions that are consistent with constructivism:

1. Exemplary teachers use management strategies that facilitate sustained student engagement.
2. Exemplary teachers use strategies designed to increase student understanding.
3. Exemplary teachers use strategies that encourage students to participate actively in learning activities.
4. Exemplary teachers maintained favorable classroom learning environments.
5. The student-perceived learning environment of the classes was related to teachers' knowledge and beliefs.
6. Teacher beliefs had a major impact on the way in which the curriculum was implemented.

In most traditional American classrooms, the student is perceived as the receiver of knowledge, or a "vessel" to be filled with knowledge. The teacher is the provider of that knowledge. The student is perceived as the passive receiver of information. Communication is mostly teacher directed and this power relationship may deprive

the student of the social construction aspect of the classroom experience. In a study done by de Esteban and Penrod (2000), a classroom climate that restrains communication would reinforce negative perceptions and feelings where the students would avoid communication altogether.

Authoritarian classrooms are those whose locus of control lies solely on the teacher as the giver of knowledge and the students as passive recipients. Gregoire and Algina (2000) conducted a study examining school climate based on how the climate relates to both academic and motivational outcomes in students in a large sample of 8th grade students. Schools were selected using two-stage stratified sampling, then selected 8th graders within these schools. A total sample consisted of 24,599 students in 1,050 schools. Data were collected using questionnaires administered to students, principals, parents and teachers. The survey results showed that schools perceived as authoritarian by students (those schools where teachers were unresponsive, etc.), had students with lower academic engagement and perceptions of control (Gregoire & Algina, 2000).

In constructivist classrooms, immersion in the subject matter on behalf of the students is more beneficial to learning than a teacher-centered classroom. According to Hansen (2000), Dewey regards student engagement and involvement as the immediate aim of teaching. Learning will more likely be the outcome if teachers cultivate classroom environments where students are engaged in activity, whether conducting scientific experiments or debating the moral ethics of controversial topics. If teachers force learning without facilitating meaningful involvement on the part of the students, frustration and disengagement may be the result (Hansen, 2000).

Educational Significance of Study

There have been a great many papers written on the topic of constructivism and its components, however very little empirical research exists regarding the constructivist approach versus the traditional approach with regard to science education; the work is mostly done with mathematics education. Most of the current research continues to be descriptive in nature rather than comparative, even though the outcomes of constructivist educational instruction are often qualitatively different from traditional methods (Applefield et al, 2001). If the constructivist approach to teaching science is truly the more desirable way to teach, then more schools should adopt the pedagogy; however if constructivism proves, in the end, to be no more successful than traditional practices, then this information is also important. Additional data need to be added to the pool of research concerning constructivism and science education.

At the root of science education reform is the call for pedagogy informed by constructivism and its infusion into science instruction. Studying the effects of constructivist informed pedagogy provides a framework for educators who wish to raise comprehension in their classrooms. This study provides information about the use of constructivist practices and their effect on student comprehension.

This research is necessary because it will provide information about the use of constructivist practices and their effect on student learning in physical science. Results of the study will provide teachers instructional practices and assessment tools that are aligned for more accurate measurement of student progress and comprehension. This study will contribute to the body of research by addressing science education and

constructivism, and whether comprehension is attained as a result of constructivist methods.

The independent variable of this study is pedagogy, either a traditional, direct-instruction approach or pedagogy informed by constructivist techniques. The dependent variables are defined as student achievement in 8th grade physical science as measured by the Virginia Standards of Learning test and a researcher-constructed Higher-Order Skills (HOS) measurement instrument.

The study will focus on Urban middle school students, specifically 8th grade physical science students. According to current definitions, "urban" means different things depending on what country is being discussed. In the United States, an urban area comprises one or more places (central place) and the adjacent densely settled surrounding territory (urban fringe) that together have a minimum of 50,000 persons. The urban fringe consists of contiguous territory having a density of at least 1,000 persons per square mile. By this definition, 75% of the United States' residents live in urban areas (Hartshorn 1992, and Famighetti (ed.) 1997, and US Census Bureau, 1995). This dissertation will be an urban study for these reasons:

1. The population of subjects consists of Urban middle school students, specifically Norfolk. Norfolk is an urban center by definition (Hartshorn 1992, and Famighetti (ed.) 1997, and US Census Bureau, 1995).
2. The subject pool will include African-Americans from an inner city school system, (the traditional Core City of Norfolk). Differences in race, if any, will be studied.

Certain questions remain unanswered in the current literature. For which learners and for what learning outcomes will constructivist pedagogy be most effective? More research is needed to answer this question, hence this study.

Statement of Purpose

The purpose of this study is to determine whether constructivist (student-centered) based science instruction is more effective than direct instruction/traditional (teacher-centered) based science instruction in terms of comprehension as measured by Virginia SOL scores and comprehension measurement scores for urban 8th grade middle school science students.

This study will explore how performance on Virginia Standards of Learning Tests and Comprehension Measurement related to constructivist vs. traditional teacher practices and the implications for gender and race. According to research, students who are taught with constructivist-based instruction score higher on comprehension measurements and have better attitudes towards science (Musheno & Lawson, 1999; Heide, 1998), and achievement is higher in constructivist classrooms that include components such as cooperative groups, and child-centered instruction (Slavin et al, 1985).

Theoretical Framework

This researcher's working hypothesis is that science is taught best using techniques that employ higher level abstract thinking skills and student-centered instruction (constructivist practices) than lower level, fact-based memorization and teacher-centered instruction (traditional or "direct instruction" practices). Students are being taught science by teachers who "teach to the test" which implies that the student can pass the

SOL test, but not necessarily score well or show comprehension of the subject matter (Carey, 1997).

Constructivism . Constructivist ideals have been with us for a long time, but have been described by other terms. Constructivism, as a theoretical framework, was set forth by psychologists Piaget and Bruner. It is an epistemology, used to explain how we humans learn. According to constructivism, knowledge cannot be transferred from the teacher to the student intact, the student constructs knowledge for him or herself based on prior experience and understanding. According to Sigel, Piaget noted that knowledge is not merely transmitted verbally but must be constructed and reconstructed by the learner, and that for a child to know and construct knowledge of the world, the child must act on objects and it this action which provides knowledge of those objects (Sigel, 1977).

Traditional (Instructivist) or Direct Instruction. The epistemology that is dominant in most classrooms today is influenced by objectivist philosophy; most teachers view knowledge as something outside the student for the teacher to give to the student. Knowledge is out there to be had, residing in books and independent of human beings (Lorsbach &Tobin, 1997).

The philosophy of objectivism posits that the Universe exists independent of consciousness. The function of consciousness is not to simply create reality, but to apprehend it (Peikoff, 1997). Objectivity is a major component of the search for truths which underlie reality; learners are encouraged to view objects, events and phenomena with an objective mind, which is assumed to be separate from cognitive processes such as imagination, intuitions, feelings, values, and beliefs (Johnson, 1987). Teachers supply textbooks, and through notetaking and lecture, the students "learn" the information.

There is usually only one way to arrive at the “truth” or correct answer. How a student arrived at the answer is not very important, just that he or she did. Traditional teaching also has been called Instructivism. Finn and Ravitch, coined the term "instructivism" to describe traditional teaching practices, focusing on teacher-centered instruction, which in their opinion, is superior to constructivism (Finn & Ravitch, 1996).

Hypotheses

The purpose of this study is to determine the effects of constructivist-informed pedagogy on science comprehension across traditional (direct instruction) and constructivist classroom environments in 8th grade middle school science.

The research questions for this study include:

1. What teacher types characterize this sample of 8th grade science classes?
2. Do children who receive instruction in constructivist classrooms perform better on achievement and comprehension tests than children who receive instruction in traditional classrooms?
3. Is there a difference in achievement and comprehension outcomes as a function of gender and teacher type?
4. Is there a difference in achievement and comprehension outcomes as a function of ethnicity and teacher type?

There are six hypotheses for this study:

Hypothesis 1: There will be a difference in achievement by teacher type as measured by SOL science scores.

Hypothesis 2: There will be a difference in comprehension by teacher type as measured by Higher-Order Skills scores.

Hypothesis 3: There will be a difference in achievement by gender and teacher type as measured by SOL scores.

Hypothesis 4: There will be a difference in comprehension by gender and teacher type as measured by Higher-Order Skills scores.

Hypothesis 5: There will be a difference in achievement by ethnicity and teacher type as measured by SOL scores.

Hypothesis 6: There will be a difference in comprehension by ethnicity and teacher type as measured by Higher-Order Skills scores.

Methodology

The sample for this study was taken from urban middle schools in a Southeastern urban school system, namely Norfolk, Virginia. The sample included Caucasian and Minority middle school science students. The study was conducted in thirteen intact classrooms, three employing traditional instructional methods, five employing conceptual/constructivist instructional methods and five employing mixtures of both, designated as mixed. Type of classroom was identified through surveys where teachers stated which type of instruction is employed in their classroom. Every 8th grade science teacher in the district was asked to complete a copy of The Revised Constructivist Learning Environmental Survey (CLES)(Taylor & Fraser, 1994), which measures teacher perception of constructivist attributes in the learning environment. This instrument is designed to measure the constructivist approaches used in teaching science. The results of this survey provide insights into classroom environments and pedagogical basis of instruction. It is a 30 question, five-point rubric or Likert questionnaire which identifies teacher perception of the presence of characteristics of constructivism on five subscales,

with six questions each: Personal Relevance, Scientific Uncertainty, Critical Voice, Shared Control, and Student Negotiation. The composite scores were used to determine a "low" (score of 30) or "high" (score of 150) degree of constructivism in the classroom environment.

Upon return of the surveys, the researcher observed each classroom and scored a copy of CLES to match up teacher perceptions to researcher perceptions. The 13 classrooms were ranked from most constructivist to most traditional.

The independent variables are:

1. Teacher Type (with three levels-constructivist, mixed and traditional).
2. Ethnicity (with two levels- Caucasian vs. Minority).
3. Gender (with two levels- male vs. female).

The dependent variables are:

1. Standard of Learning (SOL) scores
2. Higher Order Skills (HOS) scores

The primary analysis was MANOVA through which differences in SOL and HOS associated with the different methods and with race and gender were determined.

Limitations

Internal Validity issues. Perceptions of the constructivist learning environment are self-reported measures, and it can never be certain if the teachers' responses are true reflections of their attitudes, perceptions or behavior. Teachers may respond in socially desirable ways and may not be good observers of their own behaviors in the classroom, and, in turn, may think they are teaching a certain way but are not. This may be minimized by clear questionnaire definitions as to specifically what are the two types of

instructional methods and the characteristics of each (objectives), and also the researcher's observation of the classrooms after the self-assessment. Teacher efficacy could account for some of the differences in SOL and Comprehension scores instead of instructional techniques. Finally, scores are derived from traditional paper and pencil tests (Virginia 8^{th} grade Standards of Learning test) which favor students taught with a more traditional approach. Also, random assignment is not possible due to the ex-post facto nature of the study.

External Validity issues. Generalizations to other urban populations cannot be guaranteed. Selection bias may be a limitation because of the intact nature of the classrooms and the fairly small 8^{th} grade science teacher population employed in this study.

Definitions of Terms

The following operational definitions were used in this study:

Constructivism. A theory of cognition that states learners actively construct or formulate their own understanding of phenomena. While reality exists, knowledge of the world is objective, not absolute (Driver et al., 1994).

Constructivist Teaching Methods: A result of constructivist informed pedagogy which is measured by the level of conceptual understanding of the lesson, amount of interaction, inquiry, and student-assessed relevance of the lesson.

Conceptual Understanding. The level of understanding derived from experience and tied to specific instances. New ideas are connected to existing ones. To generalize an idea of a class of objects; an abstract notion. "It should be produced completely a priori and should relate to an object" (Kant, 1964, p.129).

Higher-Order Skills Test-A researcher constructed comprehension instrument developed from the Virginia Standards of Learning 8th grade science exam.

Science Classroom Observation Rubric (Burry-Stock, 1995C). A rubric written to describe the ideal practices of science teachers from a constructivist perspective. The instrument uses a behavioral rating scale to assess 18 teaching practices.

Standards of Learning 8th grade science test-a Virginia state-wide standardized test given in 8th grade to measure competence in general, life and physical science.

Traditional Teaching Methods. the process of teaching by lecture and direct instruction whereby teachers are the center of the lesson and dispense knowledge for the students to acquire through transmission. Students are involved in didactic learning where the teacher is the dispenser of knowledge and activities are decided upon by the teacher. Can also be known as Direct Instruction or Instructivism.

Urban schools. Schools that are located in areas defined as urban by the U.S. Census Bureau; these areas must contain either an incorporated place with a minimum population of 50,000 or a total population of at least 100,000 (75,000 in New England) (U.S. Census Bureau, 1990).

Chapter I presented the introduction for the study, the theoretical framework and purpose of this study. The research hypotheses and significance were presented, along with a definition of terms and the delimitations of this study. Chapter II comprises a review of the literature concerning the development of constructivism, and traditional instruction. Also included are studies addressing the value of each. Chapter III describes the research design, hypotheses, subjects, sampling, variables, instrumentation, experimental design, procedure, statistical analysis, and validity issues. Chapter IV

provides an analysis of the data. Chapter V summarizes the study and provides conclusions and recommendations.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this study is to determine whether constructivist-based science instruction is more effective than traditional science instruction in terms of comprehension as measured by Virginia Standards of Learning scores and comprehension measurement scores for Urban 8th grade middle school science students. This chapter will review literature pertinent to constructivism and direct instruction as it relates to the types, history, and classroom pedagogy. Chapter II begins with definitions and types of constructivism and direct instruction, research, instructional models and learning environments.

Constructivism

The idea that children build knowledge from their own experiences and mode of thought is the concept behind constructivism. The coining of the term "constructivism" can be traced back to Piaget's reference to his views as "constructivist" and from Bruner's description of his discovery learning technique as "construcionist" (Applefield et al, 2001). Those employing constructivist methodologies believe that real understanding occurs only when children participate fully in the development of their own knowledge, which occurs morally, cognitively, mentally and socially. "They describe the learning process as self-regulated transformation of old knowledge to new knowledge, a process that requires both action and reflection on the part of the learner...the research of cognitive psychologists and science educators over the past decade has shown that what children learn greatly depends on what they already know.

Knowledge and understanding grow slowly, with each new bit of information having to be fitted into what was already there" (Howe & Jones, 1998, p. 8-9).

Constructivism is also a philosophical explanation about the very nature of knowledge itself. As an epistemology, constructivism declares that knowledge is formed by the knower from existing beliefs and experiences. Knowledge is not independent of the knower and is not made up of accumulated 'truths'. Individuals create their own meaning from their own experiences; therefore, all knowledge must be tentative, personal, and subjective. Also, constructivism is an epistemological view of knowledge formation emphasizing construction rather than transmission and recording of information given by others (Gatlin, 1998, Applefield et al, 2001).

Constructivism also can be defined as programs that are student-centered and are based on a theory of learning that focuses on how students develop understandings (Richardson, 1999). The constructivist approach differs from the traditional (direct instruction) approach in that students are included in the learning. Teachers who instruct from constructivist pedagogy develop lessons that lead children to engage in self-directed problem solving instead of direct instruction.

"Most constructivists would agree that the transmission approach to teaching, usually delivered through lecture or direct instruction, promotes neither the interaction between prior and new knowledge nor the conversations that are necessary for intense involvement in ideas, connections between and among ideas, and the development of deep and broad understanding" (Richardson, p. 146). Teachers assess the prior misconceptions that students bring to the classroom and try to correct them through this

identification. Students use hands-on and cooperative learning situations and lessons that are student-centered based on children's basic curiosity about the world.

Also, constructivism is concerned with linking students' prior knowledge to present activities. According to McNichols, "Constructivism is a theory about knowledge and learning. Embedded in this theory are the notions that:

1. Meaning, which is represented as knowledge, is based internally in the learner.
2. The acquisition of knowledge is the responsibility of the learner.
3. Knowledge is achieved from the learner's experiences and values conditioned by reflection, inquiry, and cognitive dissension.
4. Learning is an internal process, which is enhanced through the consensual negotiation of ideas.
5. The outcome of knowledge is a pragmatic process.
6. The assessment of learning is naturally connected with the learning process (McNichols, 2000).

These tenets of constructivism imply a classroom setting where social and intellectual interaction help students form meaning of the subject matter. Thus, constructivist pedagogy does not direct teachers in what and how to teach, but urges instructors to facilitate learning by providing a condusive environment for such in the classroom.

Components of Constructivism

In order to understand constructivist practices in terms of their origins in psychology and educational philosophy, it is necessary to separate them into components, along with their corresponding research studies. The components that this paper will address are

concept formation, cooperative learning, alternative assessment, hands-on/active learning, and student-centered learning.

Concept Formation

Vygotsky stated that one of the basic components of constructivist pedagogy is the notion that children develop concepts on their own through everyday experience, called everyday concepts, and those concepts learned in school, called scientific concepts. These scientific concepts may be remote from a child's experience unless a teacher knows how to tie them into the child's experiences to make them meaningful. Conceptual change is the term that refers to the ongoing process in which children integrate their everyday concepts into a system of related concepts, including scientific concepts that have been taught in school (Howe & Jones, 1998). The following include instructional techniques that accomplish this goal.

Reciprocal Learning. On-going dialogue between student and teacher is at the heart of constructivism and helps to prevent student misconceptions of learning. To gain new understandings from one's social environment and to become a high level thinker capable of making meaningful connections requires adopting specific intellectual skills that are modeled by competent teachers. Learning-to-learn strategies may be taught to students or discovered by students as they attempt to solve problems. Reciprocal teaching is one such strategy (Applefield et al, 2001). Reciprocal learning and teaching strategy is the creation of Palinscar (1984). It is a strategy employed in order to raise reading comprehension, which includes four points:

1. Summarizing
2. Questioning

3. Clarifying

4. Predicting

The procedure consists of interactive dialogue where the teacher models the four skills, gradually letting the students take over the responsibility, while taking the role of coach. The teacher and students take turns leading a dialogue concerning sections of a text. They also take turns generating summaries and predictions and in clarifying misunderstandings in the text. The order in which the four strategies occur is not important, most teachers mold the four to the particular text being read (Jones, 1998, 1999, Palinscar et al, 1984). The goal is to encourage student regulated self-learning by helping students develop effective strategies and contextual knowledge of when to use them (Applefield et al, 2001).

In research studies conducted by Palinscar (1983, 1984), students increased their comprehension ability after receiving reciprocal teaching instruction, including modeling and corrective feedback on the four comprehension activities. The types of tasks selected for students included complex, real-life problem-based tasks, which emphasized conceptual understanding over memorization (Applefield et al, 2001). Empirical support for reciprocal teaching technique is found in several comprehension studies (Palinscar et al, 1984, 1986), and results confirmed that the reciprocal technique can build pre-reading and comprehension skills (Andrews, 1995).

According to Palinscar (1984), the goal of long-term reading instruction is not to focus on content knowledge that students to a large part already possess, but to stress comprehension-fostering strategies that extend knowledge to more areas other than reading. In a study conducted in 1984, teachers received training in reciprocal techniques

for a reading class and students were measured on criterion tests comprehension, reliable maintenance over time, generalization to classroom comprehension tests, transfer to novel tasks, and standardized tests. These measures also were taken from traditional classrooms with no intervention. Reciprocal teaching techniques accounted for significant gains in each of these measures. Many of these results were replicated during a second study (Palinscar, 1984).

Reciprocal learning improved listening comprehension as well. In a study conducted at the primary level to determine whether reciprocal teaching would be an effective approach to improve nonreaders listening comprehension, before the administration of the treatment (recripocal teaching), pretest scores were 51% correct for the reciprocal group against 49% correct for the traditionally taught group. After treatment, posttest scores were 72% for the reciprocal group against 55% for the traditional group. Reciprocal teaching was compared to traditional basal reading instruction where both sets of students read the same text from basal readers (Palinscar, 1992).

Reciprocal learning theory has as its foundation Vygotsky's learning theory. Vygotsky had unique ideas about education and socialization of children that are relevant to science teaching. These ideas were developed through observing children going about their daily business of school, family and play and emphasized the importance of interactions with others as it fosters cognitive development. Vytogsky emphasized the role of guided learning in social contexts, which is the basis of reciprocal learning (Palinscar, 1992). Vygotsky's contribution to constructivism has been identified with social constructivism because it emphasized the importance of social context for cognitive development.

Vygotsky's best known concept in the social context is called the zone of proximal development, which could be another term for reciprocal learning. It argues that students can, with the help of teachers and slightly more advanced students, master ideas and concepts that they could not master by themselves. He believed that "children should have tasks set for them that are just beyond their present capability but which they can perform with guidance from a teacher or more advanced peer. He described a 'zone of proximal development' (ZPD), as an area just beyond a child's current level of ability" (Howe & Jones, 1998, p. 31).

Vygotsky's concepts are aligned closely with science education. Today's classrooms stress cooperative learning, especially in science classrooms where laboratory experiments serve to enhance social skills and cooperation in the completion of science process and lab skills. In addition to Vygotsky, this style of teaching has at its foundation the theories of Dewey, Piaget and Bruner (Howe & Jones, 1993). There are four general principles that are applied in any Vygotskian classroom:

1. Learning and development is a social, collaborative activity.
2. The Zone of Proximal Development can serve as a guide for curricular and lesson planning.
3. School learning should occur in a meaningful context and not be separated from learning and knowledge children develop in the "real world" (Howe & Jones, 1993).
4. Out-of-school experiences should be related to the child's school experience.

Vygotsky has filled in gaps some scholars find in Piaget's work, such as not including the importance of social dimensions and their influence on intellectual development.

Vygotsky's theory suggests the inherent social nature of all humans and his work marries social with intellectual instead of divorcing the two. Socially mediated instruction as it pertains to Vygotsky is called scaffolding. The nature of scaffolding is for the teacher to provide enough support without doing the work for the student (Palinscar,1992).

Albert Bandura has also studied human behavior in a social learning theory that he calls "reciprocal determinism". In this theory, human behavior influences environment and environment influences human behavior. People and environments do not function independently of each other, rather they determine each other. This is the opposite view of behaviorism which states that a stimulus always causes a response; a one-way directional relationship. Behaviorism neglects determinants of behavior caused by cognitive functioning. Social learning theory relies heavily on self-regulating capacities within the individual, thereby placing some responsibility on the person and not solely on the stimulus. In the constructivist classroom, this would have implications for students who interact and participate in their learning rather than experiences a more passive learning experience (Bandura, 1977).

The Learning Cycle. Constructivism is based on the notion that students build knowledge by continually restructuring new information to fit existing concepts. The Learning Cycle is a conceptual-change model of instruction that is consistent with concept formation. It has several components that are similar to reciprocal learning. The three-stage model is as follows:

1. Exploration Phase-Teacher gives students materials and encourages exploration and questions about things dealing with new materials that they do not understand.

2. Concept Introduction Phase-Teacher introduces and explains key concepts, may illustrate, diagram. Textual readings become more purposeful.

3. Concept Application Phase-Teacher help the students apply the newly learned concept to new situations.

The Learning Cycle is based on the work of Piaget and his learning principles of mastery and self-regulation, where learners develop new reasoning patterns as they accommodate and assimilate new ideas. Students become reflective and as they practice new skills, they improve their cognition rather than their behavior as in the case of behaviorism, which is what drives the traditional teaching method (Ebenezer & Haggerty, 1999). Employing the learning cycle also clarifies students' thought processes and misconceptions. Students have the opportunities to explain and debate their ideas, thereby giving teachers good insight as to why students are arriving at certain answers or viewpoints (Bevevino et al, 1999).

Musheno and Lawson (1999) studied to see whether the learning cycle can be applied effectively to teach science text. High school students were randomly assigned to read either a traditional text passage or a learning-cycle passage. The students in the learning cycle group earned higher scores on concepts comprehension questions at all reading levels (Musheno and Lawson, 1999).

In addition to Piaget, accommodation and assimilation are also components of constructivism as defined by Fosnot (1989). During concept introduction, students may encounter realities than contradict their existing ideas. Cognitive conflict arises through group dynamics and social exchange as the learner realizes that there may be a contradiction between his or her understanding and what he or she is experiencing

(Applefield et al, 2001). Conceptual change theories of instruction are based on constructivist perspectives, and from this view, learning involves interactions between new and existing conceptions. Teaching is more than providing one correct view (Posner et al, 1982).

Conceptual change methods which include techniques such as learning cycles and students' changing conceptions have been shown to foster positive student attitudes. Heide (1998) demonstrated that students demonstrated more positive attitudes about science and implemented higher-order thinking skills as a result of constructivist-based conceptual change teaching.

Constructivism states that conceptual change is the key to cognitive growth and development, and so conceptual change should become the goal for every good teacher's instruction (Applefield et al, 2001). There is evidence that conceptual understanding of content is higher when students are taught in constructivist classrooms. Current research supports the advantage of conceptual learning over memorization. Constructivism has been very successful in mathematics instruction where students have historically done poorly in terms of understanding certain mathematical concepts, such as giving students relevant examples to solving analogous problems that have some connection to similar problems and prior knowledge (Chen, 1999).

Specifically, Chen (1999), conducted research concerning children's learning and transfer to determine the conditions under which and the extent to which children apply problem solutions from source to target (transfer) problems. Seventy-one children ranging in ages from 8 to 11 years old were recruited from a mid-size city. Results showed that children who a learned a general schema (concept) that applied to a problem,

had no difficulty answering problems that included formulae and enhanced their flexibility in solving the target problem. In contrast, children in the invariant group who did not learn the concept behind the formula, tended to be tied to the specific formula and so when asked to solve a problem requiring a different formula, they experienced difficulty solving the problems.

Of course, teacher competence can either enhance or sabotage constructivist learning experiences. Success with constructivism is dependent partly on teachers possessing sophisticated epistemologies and being properly trained in the technique. Some researchers go so far as to call traditional teaching techniques ‘naïve’ and constructivism ‘sophisticated epistemology’ (Howard et al, 2000).

Teachers themselves must embrace constructivist practices during professional development. Berger (1999) showed that teachers must be given learning experiences based on the same pedagogical principles as the ones they are expected to implement with students, and that if teachers are going to teach for understanding, the teachers need to be challenged at their own level of mathematics competence. During a constructivist teacher workshop developed to enhance mathematics instruction, teachers were taught that conceptual learning proceeds to the development of structures, or big ideas that can generalize across experiences. Forty-eight teachers from around the state of Florida were chosen to participate based on geographic location and teaching assignment. The intent was to do a model of K-12 team approach that would later be replicated in each of the six regions of the state. As a result of the teacher education, students scored higher on algebra tests after focusing on the concepts. More important to the students, inquiry learning, which was employed in this study, showed to result in gains over traditional

teaching methods in a wide range of students, especially with disadvantaged students deriving greater benefits (Berger, 1999).

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Schema Theory. The concept of new information being fitted into a knowledge paradigm that is already there is called *Schema.* "A schema is a general knowledge framework that a person has about a particular topic. A schema organizes and guides perception" (Hyde, 1996, p. 58) It is due to this schema concept that true higher level comprehension can occur, not just memorization. When everything connects in the mind, memorization does not have to be relied upon as the core mode of learning. Regardless of the level of sophistication of a student's existing schema, each student existing schema, or knowledge structure, will have a profound impact on what is learned and whether or not real learning (as defined as conceptual change) occurs (Applefield et al, 2001).

Schema is also about putting things into their proper context. Environments where children can interact with their peers, teachers, toys, or instructional materials, enhance their development and their desire to learn. When children play, they use their senses to experience the world; they feel, see, hear and sometimes taste the world and the objects

with which they are playing. When learning is dynamic as in this scenario, new information is placed into its proper schema or context, depending on the situation. Children develop nuances and subtleties otherwise not noticed. In this way, research has shown that too much teacher-directed instruction has either negative effects at worst or neutral effects at best on children's development (Meade, 1999). What is learned tends to be context-bound and tied into the situation in which it is learned (Lave & Wenger, 1991).

Athey defines schema as forms of thought. Athey worked with Meade on a project observing children's actions in relation to schema learning and brain development (Meade, 1999). Meade studied the effects of curriculum intervention on the richness and amount of stimulation teachers give four year olds when they observe children who are fascinated by schemas. The researchers observed 20 nursery school children at play with particular schemas, described as lines, curves and space order. Meade was interested in the study in terms of brain development and neural pathways. Results showed that the strengthening of neural pathways is enhanced by focused play, a self-organized focus on the schemas, even though adults may not see the play as beneficial. If a child showed interest in a "schema", such as being fascinated by horizontal lines that connect A to B, the teachers would give the students materials for them to connect; ribbon, string, etc. They did not give lessons, but simply observed the children. This "provision of diverse experiences" resulted in higher IQ scores because of the enrichment of the children's' experiences (Meade, 1999).

Yarlas (1999) argues that interest in a particular subject or class in large part depends on the usefulness and comprehensibility of the information, its meaningfulness to the

student, and its ability to be processed and incorporated into a person's existing schema or knowledge structure. Thus, the degree to which information attainment leads to schema enhancement seem to be related directly to the student's interest level for that information.

Yarlas (1999) chose physics classrooms and studied the effect gender had on cognitive interest. This was accomplished through assessing a learner's current state of knowledge in a domain, and creating materials that optimized the student's degree of schema enhancement. Students were read passages that contained information about either an expected or an unexpected outcome. Students were asked to either explain or describe information related to these outcomes. Schema enhancement was related to unexpected outcomes, thereby increasing interest. The data strongly supported the prediction that the more interesting the passage, the more learning occurred. Individual interest and gender were covariates because males naturally have more experience with physics and science in general, providing further evidence that supported the central hypothesis of the knowledge-schema theory; that learning increases interest for information in classroom situations where concepts are taught in ways that maximize interest.

Participants in Yarlas's study demonstrated greater learning for concepts that were related to their own knowledge-schema, than for concepts less related to their schema. This supported the prediction that the more relevant the new information is to existing information already in the child's brain, the more interesting is was for the child, possibly explaining why girls fair poorly in advanced physics classes (Yarlas, 1999).

Walker (1999) conducted a differential item functional analysis to determine if 7^{th} and 8^{th} grade students participating in the Third International Mathematics and Science

Study who were taught mathematics in a constructivist classroom had a higher probability of obtaining the correct answer to mathematics items that measured conceptual, rather than procedural understanding, than students taught in a traditional classroom. Results showed that the constructivist taught students had a higher probability of answering mathematical items that measured conceptual understanding correctly, than students taught in traditional classrooms (Walker, 1999).

Bruner contends outside forces or experiences, in addition to growth and maturation, may propel a child from one stage of development into the next. As a cognitive psychologist, the fundamental assumption of Bruner's work is that humans use mental models to represent reality. These models also can be described as modes of representing knowledge and experience:

1. Enactive- from infancy, this mode corresponds to Piaget's sensori-motor stage. This representation is experience translated into action.
2. Iconic- these representations use visual imagery and develop at age two to three.
3. Symbolic- language and mathematics systems and develop from around seven years of age.

Bruner moves into an interactionist position in his theory of learning, encompassing constructivism, and emphasizing the roles of exchange between teacher and learner in the acquisition of knowledge. He developed the notion of "The Spiral Curriculum"(Howe & Jones, 1993, p. 28), whereby the curriculum should involve the mastery of skills that lead to the mastery of higher level skills throughout a child's academic career. For example, the topic of acceleration can be taught in a simple way in first grade, to a more complex way in middle school, to a very detailed formula driven physics class in high school.

According to Bruner, learners construct their own meaning through concept formation, and that the learner selects and transforms information, constructs hypotheses, and makes decisions relying on mental models to do so. In order to operationalize Bruner's theories, teachers must be active problem solvers with expectations for the students to be interactive learners. Process is important to Bruner, therefore science education is the perfect vehicle with which to carry out his ideas.

Bruner's concept formation serves as a vital ingredient in the constructivist classroom. In a study conducted by Discenna and Howse (1998), 22 pre-service elementary education students enrolled in either a physical science or life science course were instructed by one of the authors at a mid-sized Midwestern university. The researchers were seeking to enhance pre-service teachers' scientific knowledge by changing their notions of science and their epistemological beliefs of on science learning. The authors were interested specifically in describing beliefs that students bring to the science classroom and to science learning as a meaning-making activity and how these beliefs in science may differ from beliefs about learning.

Both classes stressed problem solving and guided inquiry activities as the method of teaching science. During fifteen weeks, the subjects participated in a guided reflection task. After the course, the journals were coded into five "views" of how science should be taught. The most passive view considered science a body of knowledge or set of facts to be memorized by listening. The more active considered science to be the replicating of work by others. A middle view depicted science as existing in objects and that in order to learn, manipulating these objects to discover the "science" behind them was important. Students' ideas changed in a positive way during the semester in terms of science

learning, aiding their concept formation. The authors argue that pre-service teachers need more classes in the inquiry/problem-solving tradition with teacher mentors. When pre-service teachers are trained in schema-theory, they begin to understand that the notion of science making and science learning as a meaning-making enterprise. This is very important in fostering the same traits in students once the teachers reach the classroom (Discenna and Howse, 1998).

Cooperative Learning/Social Learning

Dewey is considered the father of modern American education. He led the way for progressive education reformers at the turn of the century. Dewey held that education was composed of four main objectives: intellectual, moral, social and aesthetic development. The development of the whole child became the goal. Although the term 'constructivism' is never to be found in Dewey literature, his philosophy is the buttress of the whole constructivist movement (Dewey, 1916).

Dewey was the first philosopher to recognize the social as well as the intellectual aspects of learning. He wrote of "education as a social function" whereby teaching consists of "social direction" (Dewey, 1916, p. 31). Note that the role of teaching according to Dewey is not to lecture and impart knowledge, but to direct student activity to discover their own knowledge. The classroom consists of a "social environment" (Dewey, 1916, p. 14).

Indeed, social constructivism, supports cooperative learning. According to Vygotsky, children develop in social or group settings. Instead of working alone, children benefit when the teacher serves as the guide, encouraging students to work in groups to discuss

issues and challenges that are rooted in real life situations. Teachers thereby facilitate cognitive growth and learning, as do their peers (Anonymous, 2000).

Cooperative learning is based on the Deweyan notion of social learning. Science is the perfect curriculum area for the employment of cooperative learning, since the very nature of scientific exploration includes social learning between laboratory partners. Much empirical evidence exists suggesting that cooperative learning enhances not only a more thorough mastery of skills, but also social and communication skills as well (Slavin, 1983). In sum, Dewey reformulated the framework for education, by stating that learners make sense of new information by placing it in already existing schema, a basic part of constructivism. He dramatically influenced education, and continues to have great presence in the educational arena.

Cognition is viewed as a collaborative process and constructivist thought provides a theoretical basis for cooperative learning, which points toward the powerful social aspect of learning. Students are exposed to their peers' thought processes and opposing views. Constructivists also make use of cooperative learning tasks in relation to learning and comprehension, as well as peer tutoring. Students learn best in situations where they dialog with each other about problems (Applefield et al, 2001).

Johnson and Johnson (1994) state that the effectiveness of cooperative learning has been confirmed by both demonstration and theoretical research. Achievement is greater when learning situations are structured cooperatively rather than competitively or individualistically; students focus both on increasing their own achievement and that of their groupmates (Johnson & Johnson, 1994). Cooperative learning experiences promote greater critical thinking skills, more positive attitudes about science, greater collaboration

skills, better psychological health, and greater perceptions of the grading system as being fair.

Students' notions about science also are affected by cooperative learning. Science is learned by doing and is interwoven with problem-solving activities aimed at involving students in the concepts of science, as well as the pursuit of the scientific method. Teachers have the power to incorporate cooperative learning into their classrooms. According to Yager, principal investigator for the Salish Project (1997), teachers who hold student-centered beliefs were likely to have completed teacher-education programs in which they participated in cooperative learning themselves.

A number of positive outcomes have been attributed to cooperative groups, especially among girls. When done correctly, cooperative learning is designed to reduce competitiveness while increasing cooperative spirit, heterogeneous and racial relations, and boosting academic achievement. Teachers must be aware of potential problems with cross-gender cooperative groups because boys can tend to become dominant in the group and suppress the girls' learning (AAUW Report, 1992).

In a study done by Slavin et al (1984), 504 mathematics students in Grades 3,4, and 5 in a suburban Maryland school district were assigned randomly to one of three conditions: Team Assisted Individualization (cooperative groups), individualized instruction, or without student teams, or control (this group used traditional methods). These treatments were implemented for eight weeks in Spring, 1981 to evaluate the effects of cooperative learning on achievement, attitudes and behaviors of the students. The cooperative groups gained significantly in achievement than the control group. The results on the "Liking of Math" scale showed indicated a significant overall treatment

effect. Statistically significant overall treatment effects were found for all four of the behavioral rating scales. Six more experiments were conducted. In each of these, classes using cooperative groups were compared to untreated control classes on a variety of dependent measures. In five of the six studies, achievement in the cooperative classes was significantly higher than in the control classes (Slavin et al, 1985).

Heide (1998) has demonstrated that students' attitudes towards science are more positive when they engage in behaviors such as choosing problems and finding solutions to those problems (student-centered), working in large and small cooperative groups, performing hands-on science laboratory experiences and learning through conceptual understanding rather than memorization.

Alternative Assessment

Assessment should match instruction. When teachers teach mostly knowledge level fact-based curricula, they assess this way also. The problem lies in how to assess students who are learning at higher levels in more constructivist based classrooms. Among the most important aspects of teaching is reaching agreement on how to determine if the learner can demonstrate in some fashion the desired learning outcome or performance (Applefield et al, 2001).

There are several ways to operationalize ideas about teaching at higher levels. The first is to employ Benjamin Bloom's Taxonomy of cognitive levels. In 1956, Bloom developed a classification system whereby intellectual behavior important to learning was separated into three domains: Cognitive, Psychomotor, and Affective. The Cognitive Domain was further divided into six levels, which demonstrate different intellectual

skills. These go from the lowest levels of learning to the highest. (Verb examples are included that represent measurable intellectual activity).

1. Knowledge (lowest level) arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce.

2. Comprehension: classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate.

3. Application: apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write.

4. Analysis: analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.

5. Synthesis: arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write.

6. Evaluation: (highest level) appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, core, select, support, value, evaluate.

(Bloom, 1956).

The mathematics included in science intimidates many students. Not only do science students have to memorize mathematical formulae, they are then asked to grasp difficult scientific theory in application of the concepts. The problem lies in assessing the higher levels of learning, where memorization is the lowest (Bloom, 1956). Basically, teachers employing constructivist techniques teach at higher levels than are found in most current classrooms. Lower level instruction is very easy to evaluate and assess, namely multiple-choice, true/false tests.

Although historically, students taught in both traditional and constructivist classrooms may or may not score similarly on multiple-choice tests, in questions dealing with comprehension, constructivist-taught students had the edge. In a paper presented to the American Educational Research Association conference, it was reported that middle school students who were taught math in a more student-centered conceptual way, had a higher probability of obtaining the correct answer to mathematics items that measured conceptual rather than procedural understanding. The students in this study were 13-year old 7th and 8th graders, who participated in the Third International Mathematics and Science Study (TIMMS). They were administered multiple-choice mathematics items from the TIMMS test as the measure of mathematics ablity. Performance expectations included knowing, using routine procedures, reasoning, and communication. Content areas covered fractions, number sense, algebra, data representation, and analysis and probability. A variant of matrix sampling was used in the test design. Differential item function analysis was used to analyze the data.

Results measured more of a conceptual understanding of mathematics and also a gain for students taught in a more student-centered environment. The students tested also were more successful in obtaining the correct answer to mathematics items that measured conceptual, rather than procedural understanding. According to Walker, students should have acquired a conceptual understanding of the mathematics being taught, knowing not only *what* to do but *why* they were doing it. The conceptual understanding acquired by these students should enable them to apply their knowledge in new mathematical situations (Walker, 1999).

In a study that examined teachers' student learning outcome goals and their corresponding assessment practices, Bol and Strage (1996) note that although the national trend is toward integrating the science curriculum into students' daily life aimed at conceptual understanding rather than memory of content, teachers' assessment styles show little correspondence between these goals and actual teaching practices. In fact, teacher developed classroom tests contain mostly low-level questions in terms measuring knowledge. Although teachers' instructional goals were meant to promote higher order thinking skills, the test items included on their assessments do not reinforce those goals (Bol and Strage, 1996). Research also has shown that science teachers stress memorization over conceptual understanding (Gallagher, 1991), thereby reinforcing the need for multiple-choice assessments.

Alternative types of assessment (also called authentic assessment) can be compared and contrasted to more traditional assessment practices that would include standardized tests that feature closed-ended questions. Scores on standardized tests reflect whether or not a student selected the correct answer, but do not reflect the level of comprehension or problem-solving strategies used to arrive at the answer. Bol et al (1998) conducted a study where 893 teachers in a large mid-western urban school district were surveyed to determine assessment practices and their perceptions concerning their practices. Data were analyzed using ANOVAs, and results showed that among teachers in the field, elementary teachers are more likely to use alternative assessment methods than higher-grade teachers, and math teachers reported employing alternative assessment more frequently than did science and social studies teachers (Bol et al, 1998).

According to Shepard (2000), a broader range of assessment instruments is needed to measure learning goals and processes and to connect assessment directly to ongoing instruction. While multiple choice standardized tests are appropriate for measuring certain levels of acquired knowledge, Shepard suggests more open-ended performance tasks for measuring higher level thinking skills. Not only do teacher made tests measure low-level thinking skills, so do state and district tests. Statewide accountability tests (such as the Standards of Learning in Virginia), used to measure basic knowledge in science, have been corrupted with a heavy-handed rewards and punishment system doled out by administrators who do not reward the excitement of ideas (Shepard, 2000). Types of alternative assessment that would ensure the proper measurement of higher-order thinking would include both informal and formal assessment tools. Some less formal evaluations would include feedback from teacher to student, dynamic on-going assessment instead of a one-shot final test grade, self-assessment, and teacher assessment. More formal would include portfolios, rubrics and performance-based assessment. Assessment for learning must overcome assessment for passing tests (Shepard, 2000).

According to Gega and Peters (1998), these alternative assessment tools successfully measure higher-order thinking skills:

1. Performance-based assessment-models based on scientific concepts, experiments, journals, written material including papers.

2. Projects-requires self-assessment from start to finish. Students display critical thinking, persistence, inventiveness, and curiosity.

3. Peer or Self-designed instruments- rubrics, surveys. Promotes independence and ownership.

4. Interviews-are effective ways of gaining information with students with writing problems or with very early elementary aged students who cannot express themselves in writing.

5. Journals- useful ways to get students to write to learn.

6. Portfolios- a sample of work collected over time, a good self-assessment tool.

7. Concept maps- organizes thoughts and concepts. Helps to see how things are connected, including old and new information.

8. Teacher observations- an informal, on-going tool that puts learning in context.

9. Questioning techniques- open ended questions where there is more than one correct response (Gega & Peters, 1998).

In justifying alternative assessment, Gardner (1983) posits that there are at least seven types of intelligence to be found in schoolchildren. He names these as linguistic, musical, logical/mathematical, spatial, bodily/kinesthetic, interpersonal, and intrapersonal. By today's standards, only two of these areas are measured by standardized tests, linguistic and logical/mathematical. Alternative assessment measure students' understanding of content more thoroughly and completely than multiple-choice retention tests (Gardner, 1983; Armstrong, 1994).

The changes called for in instructional practices require an adjustment in the types of assessment tools used to evaluate learning. It would not be a coherent strategy to ask students to perform a wide range of high level learning experiences and then measure their progress solely on the basis of standardized multiple choice tests.

Student-Centered Learning

In discussing the nature of science, Clough (Sept/Oct. 2000) argues that significant consensus exists regarding many issues appropriate for middle and high school students. Some of the most important of these ideas for helping students better understand the nature of science include: science is not the same as technology, a universal, ahistorical scientific method does not exist, science is not completely objective, knowledge is not democratic, words used in science may not mean what students think they do, science is bounded, anomalies do not always result in rejection of an idea, scientific thinking often departs from everyday thinking. Clough suggests that students' understanding is woven into the fabric of their prior experience, which is useful in helping them make sense of new experiences (Clough, 2000).

The old out-of-date (traditional) trend in middle school science education was the idea that teaching is the transmission of discrete facts, pieces of information and specific processes. The current trend is a broader, more holistic approach that encompasses several areas of instruction, which, in turn, enhances students' understanding and comprehension. Among these are: concepts, processes, applications, attitudes, creativity and the nature of science. When science instruction focuses solely on transmission of information, only two domains of science are addressed; concepts and processes. Students are presented with a very restricted view of science. This holistic approach develops higher levels of understanding and enables students to "do" science themselves (Daas, 2000). The Western view of the classroom has held that the student is the receiver, not a producer of information. The teacher is idealized as the ultimate source of knowledge and as a highly efficient manager (de Esteban & Penrod, 2000). In a

constructivist classroom environment, the teacher's role changes to one of guiding rather than telling the learner the information (Applefield et al, 2001).

For much of the 20th century, teachers sought to teach facts in a lecture format to students. Now, educators know that teaching children how to think, solve problems and process information is more important than teaching them to memorize facts. Taba adhered to the Deweyan philosophy of education, and agreed with his brand of empiricism (pragmatic instrumentalism) in which "facts" are used to illustrate ideas and not the other way around. Taba believed that teaching should be organized through key concepts, where content should not be seen to dominate any chosen instructional method (Guyver, 1999).

Taba posits that teachers rely too much on subject matter, forcing them to decide which content to include and exclude by the end of the school year, although she warns against going too far in either direction, stating, "As a result of a strong reaction against the emphasis on subject matter found in the traditional type of school, progressive education has regarded the child too much as a psychological phenomenon, failing to realize fully that the experience of the child is a product of its contact with the objective materials of its environment. Instead of subject matter alone doing it, the child only is now dictating educational procedure" (Taba, 1932). Taba's response to increasing the knowledge base is to emphasize the "acquisition, understanding, and use of ideas and concepts rather than facts alone." This reduces the amount of detail to be covered in class, and it provides better conceptual links between pieces of factual information. Broader categories of knowledge like concepts, generalizations and conclusions act to

impose structure on factual bits of information, linking these specific bits in categories so that a large amount of specific detail is subsumed within a limited number of ideas.

Taba developed a model to categorize information. It is a multi-purpose approach that provides an occasional teaching option. The method involved three stages:

1. Students make an exhaustive list of observations, ideas, or concepts.
2. Students gather all similar items together.
3. Students name each category. They then are assigned to category groups and proceed to research their topic. The teacher's role is to facilitate acquisition of relevant information sources. The final product is a report, portfolio, project, or video presentation (Armstrong, 1998).

Taba also writes that conventional instruction does not reach those adolescents with cultural and educational deficits and that traditional instruction does not meet the needs of these students, because it is incompatible with the needs of those students (Taba, 1966). Unfortunately, most students today who have educational deficits are poor, minority, and urban, due in part to lower teacher expectations, lack of educational support at home, and lack of funding for poorer schools. Socio-economic status is the best predictor of both grades and test scores (Bailey, How Schools Shortchange Girls: AAUW Report, 1995, Wilson, 204-205).

Student-centered classrooms have been the topic of empirical study as well. In a study conducted by Chang (1994), constructivist, student-centered classrooms produced students who scored much higher when asked to explain certain scientific phenomena, than students in traditional classrooms. A sample of 363 8th grade students in a junior high school in Taipei, Taiwan were divided into three groups. All groups were given

multiple choice tests, and the scores on the tests were similar in both groups. The difference showed up in the comprehension (as evidenced by explanations) of the subject matter. Also, a teacher main effect appeared in the results of the 3x2x2 and 3x3 ANOVA analysis, indicating that teachers made significant differences on students' post-test scores. However, results indicate that teacher characteristics, more so than teaching technique, contributed to the results (Chang, 1994).

Dunkhase et.al (1997) conducted a study comparing a more student-centered environment against a teacher-centered environment and outcomes concerning student attitudes and perceptions. The study focused on student perceptions of their science instruction and student attitudes toward science learning as a function of their exposure to interactive-constructivist teaching strategies aimed at student ideas, utilization of literature integration, and incorporating parents as partners. Among the components of the student-centered environment were interactive-constructivist teaching strategies designed to focus on student ideas, shared control, listening to students' ideas, and making ideas and practices meaningful at the individual student level. Two groups were designated, students from classsrooms where teachers were instructed in constructivist philosophies, and students from classrooms without such instruction. The results showed that attitudes and perceptions were higher in the constructivist/student-centered classrooms than in the traditional classrooms. Of note is the fact that girls experienced the highest rise in attitudes and perceptions concerning the teacher delivery approach, while boys experienced a rise in positive attitudes concerning content.

Active learning includes student participation. Participation encourages students to exchange ideas and viewpoints freely in order to clarify, evaluate, and reconstruct

existing schema. In fact, the very effectiveness of a constructivist approach depends on students actively participating in classroom activities. Research shows that constructivist classrooms can increase students' ability to reconstruct their knowledge and that students in constructivist classrooms are challenged to be more active learners (Tomasini et al, 1990, Applefield et al, 2001).

Research also shows that students learn more when they have some ownership in the learning process; the basis of constructivism. Yager, et al. (1997) states that science students viewed science as more relevant to their daily lives than mathematics was to mathematics students, and that new teachers recently graduated from teacher colleges saw themselves and their classrooms as very student-centered. This study also states that more teachers think they are student-centered when actually their classes are teacher centered, however, students who behaved in student-centered ways were taught by new teachers who held coherent student-centered philosophies of teaching.

Yager, et al. (1997) also showed that teacher education programs are crucial for teachers who want to be student-centered in philosophy. Among the findings in this area are these:

*Student-centered actions were not observed in classes taught by new teachers whose philosophies of teaching were not coherent with their practices.

*Students who behaved in student-centered ways were taught by new teachers who held a coherent student-centered philosophy of learning.

*New teachers holding student-centered beliefs were likely to have completed teacher preparation programs were they engaged in cooperative learning, were assessed of their performance in the field, and had strong, close personal relationships with faculty.

*Student-centered teachers were more likely to have completed a longer student teaching experience (Yager,1997).

Developmental Stages/Readiness

Jean Piaget made huge contributions towards our current knowledge of intellectual and cognitive development. Piaget brought to light the constructivist notion of readiness; or how children learn in relation to what stage of development they are in currently. Constructivism states that children bring different levels of abstraction, knowledge and understanding to every learning experience, based on cognitive readiness. This concept is where the child-centered constructivism component developed.

Carol Gilligan conducted research with girls to study self-esteem. Gilligan's work is relevant to science education. The ways in which girls view groups or webs of relationships as being the most important aspect of their lives, is reflected in data that shows that girls learn best in cooperative learning situations (Bailey, How Schools Shortchange Girls, The AAUW Report,124-126.) Research abounds with accounts of girls who, although superior to boys in science in elementary school, somehow disengage by middle school to the point where almost no girls occupy spots in advanced placement science classes in high school. If girls show that they can hold their own in the science classroom, they run the risk of being "cut off" socially not only by boys, but by many of their girl friends as well. The result is that there are two children, one male and one female, both highly intelligent and perceptive, though in different ways, with different conceptions of understanding the world. Science is a social subject by its very nature, children have to work together in lab groups and cooperative situations. Since girls assume human connection naturally and begin to experience separation as a new

experience, boys assume separation and begin to experience connection as their new experience (Gilligan, 1993).

This theme of being abandoned socially, is Gilligan's other main theme of her work; that girls value connecting and webs of relationships at all costs, where boys value just the opposite: disconnecting and individuality. Girls will submerge their intellectual ability in order to fit in to their highly prized social group in order to belong. As a result, science and math are the first scholastic subjects to show the effects. In short, Gilligan brought to light how girls bring their own meaning to situations that may be different from their male counterparts and originating from different life experiences, once again a constructivist notion (Gilligan, 1993).

Constructivist Learning Environment

Since Constructivism does not tell the teacher what former experiences students should have, it does caution teachers against instructional techniques that may limit student understanding. Knowledge is not objective, but the teacher organizes information around conceptual clusters of problems, questions and discrepant situations in order to engage the student's interest (Hanley, 1994).

Driver has identified certain features that should be present when science is taught from Constructivist pedagogy:

1. Identify and build on the knowledge that learners bring to the lesson.
2. Allow the learners to develop and restructure this knowledge through experiences, discussions, and the teacher's help.
3. Enable pupils to construct for themselves and to use appropriate science concepts.

4. Encourage pupils to take responsibility for their own learning.

5. Help pupils develop understanding of the nature of scientific knowledge, including how the claims of science are validated and how these may change over time (Driver, 1989, p. 86).

Brooks and Brooks (1993) pose the following as their description of a constructivist classroom setting:

1. They free students from the boredom of fact-driven curriculums and allow focus on large ideas.

2. They turn over to the students the power to follow trails of interest, to make connections, to reformulate ideas, and to reach unique conclusions.

3.They share with students the important message that the world is a complex place in which multiple perspectives exist, and truth is often a matter of interpretation.

4.They acknowledge that learning, and the process of assessment, are elusive and messy endeavors that are not easily managed (p.32).

To date, many researchers have proposed models of ideal classroom environments. Excellent science classrooms are managed by teachers who use strategies that facilitate sustained student engagement, increase student understanding and comprehension of concepts and scientific knowledge, and encourage student participation in an active learning environment. A recent study suggests that there are advantages of participatory classroom environments, where students construct their own sensory input and make inferences in that information to draw conclusions (Strage & Bol, 1996).

Constructivist classrooms foster communication between students and teachers and among students themselves. Communication apprehension (CA) or "fear to communicate" was studied as a response to teacher philosophies in the classroom. A purposefully selected sample of 61 student teachers during their education program were given the Personal Report on Communication Apprehension to identify their levels of communication apprehension. A Pearson r was used to analyze the data. Results showed that high levels of communication apprehension are related to non-constructivist previous school experience. These people are assumed to have had experienced more traditional teaching styles by their teachers while in school (de Esteban & Penrod, 2000).

Howe & Jones offer this outline of the major contributors to the constructivist movement and their implication for the science classroom (see Table 1).

Table 1

Constructivism in Science Teaching

SCHOLAR	MAJOR IDEAS OR THEMES
Piaget	Children acquire knowledge by acting and thinking. Knowledge is classified as physical, logico-mathimatical, or social. Development of logical thinking is a maturational process. Understanding of natural phenomena depends on logical thinking ability.
Bruner	Children learn by discovering their own solutions to open-ended problems. Knowledge is represented in enactive, iconic, and symbolic modes. Appropriate ways can be found to introduce children to any topic at any age. The process of learning is more important than the product.
Vygotsky	Children learn through interaction with peers and adults. Knowledge is built as a result of both biological and social forces. language is a crucial factor in thinking and learning. Children need tasks just above their current level of competence.
Kohlberg	Children learn moral and ethical behavior by example rather than by teaching. Moral development is a slow, maturational process. moral dilemmas that have no easy solution are part of life.
Recent Studies	Learning is domain-specific. Misconceptions about natural phenomena interfere with new learning. Both procedural and declarative knowledge are important (Howe & Jones, 1993).
IMPLICATIONS FOR SCIENCE TEACHING	
Piaget	Provide environment to encourage independent action and thought. Distinguish between kinds of knowledge in planning instruction. Be aware of children's level of thinking.
Bruner	Use open-ended problems in science regularly and often. Use all Three models of teaching and testing for understanding. Emphasize processes of science. Teach concepts and processes that will lead to further learning.

Table 1 (con't).

Constructivism in Science Teaching

SCHOLAR	MAJOR IDEAS OR THEMES
Vygotsky	Encourage pupils to work together and to learn from each other. Encourage children to explain what they are doing and thinking in science. Set tasks that challenge children to go beyond present accomplishment.
Papert	Make sure that children understand the meaning of their class activities. Make the computer a tool for new learning, not a substitute for a book. Encourage and model thinking about thinking.

(Howe & Jones, 1993)

Bowers offers the following instructional model operationalizing constructivism (see Table 2).

Table 2

Operationalizing Constructivism

Introductory	Concept Formation	Exploration
	*Students use descriptive science processes	*Hands on experiences *Guided Discovery *Guided questioning
Develop-mental	Data Interpretation	Conceptual Invention
	*Students identify and investigate relationships *Make inferences	*Student discussion groups *Teacher-directed discussions *Students form concepts
	*Use integrated science processes	*Comparison of student concepts with expert concepts
	Application of Principles	Application
Culmin-ating	*Students make predictions and hypotheses *Support and justify predictions and hypotheses *Test predictions and hypotheses *Verify predictions and hypotheses	*Concept expansion *Extended research *Investigation of science/ technology/society issues

(Bowers, 1991, p. 7).

Development of Direct Instruction

Direct Instruction

Traditional instructional technique is the current instructional strategy based on this philosophy and is based on 100 years of research. The term "Direct Instruction" was coined by Engelmann. From 1966 to 1969, Engelmann was involved in a number of grant-funded projects aimed at exploring the extent to which special instructional methods and innovative curricular approaches would enhance the learning of children. It was during this period that Engelmann coined the term "direct instruction" and formalized the logic and methods for the operationalization of this instructional method. Engelmann's early work focused on beginning reading, language, and math. It was published by Science Research Associates in 1968 under the trade name DISTAR (Direct Instruction System for Teaching And Remediation). Over the past three decades, the original curricula have been revised and new ones developed. These curricula have been incorporated into the comprehensive school reform model known as the Direct Instruction Model, which has been implemented in some 150 schools nationwide (Anonymous, 2000).

There are several working definitions for direct instruction. Direct instruction is described by McDermott in this way: "Instruction in introductory physics has traditionally been based on the instructor's view of the subject and instructor's perception of the student" (McDermott, 1993, p. 295). The teachers in this scenario are eager to transmit their knowledge to the student. Generalizations often are formulated upon introduction, and students are not actively engaged in the process of abstraction and generalization. The reasoning is almost entirely deductive, very little inductive thinking

is involved. McDermott states; "The trouble with the traditional approach is that it ignores the possibility that the perception of students may be very different from that of the instructor. Perhaps most students are not ready or able to learn physics in the way that the subject is usually taught (McDermott, 1993, p. 295).

In contrast to supporters of constructivism, proponents of direct instruction believe that:

1. External reality does exist independently of the observer.
2. Humans have organized knowledge into systems to better understand reality: such as mathematics, biology, literature, and history among others. The role of teachers is to help students acquire this knowledge.
3. Direct instruction proponents believe that educators are guided by the main concepts of "behavior" and "learning". Behavior is anything students do that is observable. However, direct instruction also cares about how students feel, think and act.
4. The second main concept is learning, defined as a change in behavior that results in direct interaction with the environment, i.e. from teaching-systematic or incidental (Kozloff, LaNunziata & Cowardin, 1999).

Marchand and Martella developed a system to use while observing practicum teachers delivering a direct instruction lesson (see Table 3).

Table 3

Definitions of Correct Direct Instruction Behaviors

Presentation-
Cue- Focus word, phrase, or question (e.g., what word?, get ready) as indicated by program format or as specified by teacher.
Pause- At least a 1 second waiting time (preferably 2 seconds)

Signal- Hand, touch, or auditory response presented by teacher which initiates a pupil response.

Responses-
Group- Two or more pupils respond simultaneously and correctly
Individual- Pupil responds correctly

Signal Error Corrections-
Address- Corrects within 3 seconds after group error occurs; addressed to group; positive tone (without negative comments or gestures); tells group what they have to do (e.g., *I've got to hear everyone. You have to wait until I signal)*
Repeat- Repeat original presentation to test group's response; positive tone (without negative comments or gestures)

Response Error Corrections-
Model- Corrects error within 3 seconds after group/individual error occurs; addresses model to group (if group response) or individual (if individual response); positive tone (without negative comments or gestures); demonstrates correct response to pupil(s).
Test- Requests group/individual to respond again using original cue provided before error occurred; addresses test to individual if individual response or group if group response; positive tone (without negative comments or gestures)

Praise Statements-
Specific- Precise statement that reflects a positive response to a desired behavior (e.g., *Nice job saying* brother) which is delivered after an appropriate behavioral or academic response (e.g., pupil is sitting quietly with hands folded).
General- Global or broad statement that reflects a positive response to a desired behavior (e.g., Super) which is delivered after an appropriate behavioral or academic response (e.g., student completes homework assignment)

(Marchand, Martella and Kraft, 1997).

As is shown, direct instruction relies on teacher-centered lecture, with students having one correct answer. According to McDermott, the reason many students do not understand subjects like physics is that the teachers rely solely on transmitting knowledge from themselves to their students, and that the trouble with the traditional approach to instruction is that it ignores the possibility that the students may have a different perception of the subject than the teacher has. Most science teachers view their students as mini-versions of themselves, when that is not the case.

McDermott also offers these shortcomings of traditional instruction:

1. Facility in solving quantitative problems is not an adequate criterion for understanding. Questions that require qualitative reasoning and verbal explanation are essential.

2. A coherent conceptual framework is not usually the outcome of traditional instruction: Students must participate in the process of constructing qualitative models that can help them understand relationships and differences among concepts.

3. Certain conceptual difficulties are not overcome by traditional instruction. Persistent conceptual difficulties must be addressed by repeated exposures in more than one context.

4. Growth in reasoning ability does not result from traditional instruction and scientific reasoning skills must be cultivated.

5. Connections among concepts, formal representations, and the real world are lacking after traditional instruction. Students need practice in interpreting physics formalism and relating it to the real world.

Teaching by telling is an ineffective mode of instruction for most students. Students must be intellectually active to develop a functional understanding (McDermott, 1993).

Another term used for direct instruction is "instructivist" approach, a term coined by Finn and Ravitch in 1996 in their report "Education Reform 1995-1996, A Report from the Educational Excellence Network to its Education Policy Committee and the American People". Finn and Ravitch argue that constructivism is faddish and that it excludes content. In a paragraph headed "The Romance of 'Natural Learning'", they posit that constructivism is "hostile to standards, assessments and accountability" (Finn & Ravitch, 1996).

Finn and Ravitch also argue that too much constructivism means kids who can neither read nor write, although they may have curiosity and self-esteem. Although keenly pro instructivist, they also argue for a balance in the classroom. The best teachers are not a slave to dogma, they are able to employ constructivist and instructivist techniques as the situation and child require (Finn & Ravitch, 1996).

Hirsch (1988) in his book Cultural Literacy, wrote that a content-based curricula was preferred, which ran counter to Progressive educators' beliefs that natural development, process and critical thinking skills were goals to be met by education. For Hirsch, the fault with American education lay with the theories of Rousseau whose ideas influenced John Dewey, claiming that Dewey advocated the content-neutral curriculum (Berube, 1994).

Advanced Organizers. Ausubel's contribution to learning theory includes his belief that humans acquire meaningful learning through an interaction of newly learned information with relevant existing ideas in cognitive structure. Ausubel explored the process of what

he calls meaningful learning and how it relates to a learner's cognitive structure. His "Theory of Meaningful Verbal Learning" was unveiled in his 1963 book The Psychology of Meaningful Learning. He also promotes the arrangement of school curriculum to match student readiness, which shows influence of Piaget.

Although Ausubel openly supports direct instruction, he also writes that the learner must make an intellectual link between newly learned information and that previously stored in his or her cognitive structure. Because of this connection, retention is greater and understanding is significant.

In order to facilitate new learning, Ausubel advocates advanced organizers; outlines of material yet to be learned, a type of summary of material that highlights key concepts and propositions for the students. Knowing that the brain builds knowledge in a hierarchical structure and by assimilating new knowledge with the help of advanced organizers, the learner builds anchors for future knowledge (Members of the First BSU Doctoral Program for TE660).

There is empirical support for direct instruction. In a study supporting traditional methods, 138 students (including 23 mildly handicapped students) in grades 4 through 6 participated in a study aimed at comparing the effectiveness of two teaching techniques (direct instruction versus discovery teaching) in three elementary schools in a suburban Chicago school system on achievement. Students were randomly assigned to one of two treatments: direct instruction or discovery teaching. A 2 x 5 factorial design was employed. Results showed that students in both groups learned equally well as measured by a posttest. However, students in the discovery treatment group outperformed their

direct instruction peers on a delayed posttest administered two weeks after the treatment ended (Bey, et al, 1992).

Project Head Start, a grant funded by the U.S. Department of Education between 1969 and 1972, was directed by Englemann. The purpose of the grant was to provide a comparison of the different models of educational programs for disadvantaged children. Children in three Engelmann-Becker models were compared with children in other models of instruction. This was called the largest controlled comparative study of teaching methods in history. The Engelmann-Becker model worked with twenty school districts to implement effective instructional programs in grades 1 through 3 as part of Head Start. Research focused on specific variables that made a difference in student performance. Results showed that students in Direct Instruction classrooms had placed first in reading, math, spelling and language. Even though no other model was as effective, Direct Instruction has been spurned by the majority of the educational establishment (Anonymous, 2000).

Direct Instruction advocates posit that behavior is anything students do, and therefore, learning is a change in behavior (feeling, thinking, acting) that results from interaction with their environment. The instructivist approach in education means that educators draw on literature on how students learn to design appropriate curricula, and focus on changes in students' behavior (learning) as a way of tracking progress (Applefield et al, 2001).

<u>Operationalizing Instructivism</u>

According to Kozloff et al, there are basically three distinct approaches to teaching using the instructivist method:

1. Applied Behavior Analysis: (Kozloff, 2000,2001) The first branch of instructivist technique is really a combination of practices derived from years of experimental research on how environmental events and arrangements affect learning and principles of operant learning, found in the work of B.F. Skinner. These tenants are as follows:

A. Methods for examining the interaction of students with their environments so that relationships may be discovered, i.e., one can find out how a student's learning is helped or hurt by such things as difficulty, pacing, and assistance from the teacher, or the nature of their interaction with peers.

B. Guidelines for using knowledge of functional relationships between environmental features and a student's learning, to design instruction that is consistent with a student's skills.

C. Methods of evaluating the adequacy of curriculum and instruction by tracking students' learning, and revising curriculum and instruction accordingly.

2. Precision Teaching: (Kozloff, 2000,2001).Developed by Ogden Lindsey and associates. Lindsey based precision teaching on Skinner's discovery that the rate of behavior (# of occurrences/time) is a dimension of behavior, and not just a measure of the behavior. This implies a difference in fluent vs. non-fluent behavior. The following are features:

A. Teachers identify and teach the "tool skills" (component or elemental skills and knowledge) needed to learn complex skills and knowledge. For example, listening to a teacher, taking notes, having fluency with math facts, etc. When students are not fluent with tool skills (reading and writing), they are not able to learn complex skills.

B. Teachers provide carefully planned, short practice sessions on older and new learning to strengthen retention.

C. As students master component skills, teachers help students to assemble component skills into complex activities.

D. Teachers help students keep track of their own progress.

3. Direct Instruction: (Adams & Englemann, 2996).This third branch of the instructivist approach grew out of the work of Englemann and his work with disadvantaged children. Direct Instruction was compared with 12 other methods of instruction during the largest educational study ever conducted and results showed that direct instruction was superior in fostering reading and math skills, higher-order cognitive skills, and self-esteem (Adams & Englemann, 1996).

A. Direct Instruction focuses on cognitive learning- concepts, propositions, strategies and operations.

B. Curriculum development involves three analyses: knowledge, communication and student behavior.

C. Instruction teaches concepts, strategies and operations to greater mastery and generality. Direct instruction focuses on big ideas.

D. Concepts are not taught in isolation from each other.

E. The analysis of knowledge is used to create student-teacher communication.

F. Lessons are arranged logically so that students first learn what is needed to grasp later concepts.

G. Lessons are formatted so teachers know what to say and what to ask that enables students to reveal understanding and/or difficulties.

H. Lessons are followed by independent and small group activity.

I. Gradually, instruction moves from teacher guided to more student guided.

J. Short proficiency tests are used about every ten lessons (Kozloff, LaNunziata & Cowardin, 1999).

Bowers (1991) offers a way to differentiate between constructivism and more traditional direct instruction teaching techniques in actual classroom situations. Bowers sites Tickle who writes that the core teaching issue in middle school is the tension between the two instructional approaches; as he puts it, "one emphasizes the mastery of skills in content and the other stresses providing for the developmental needs of young adolescents" (Bowers, 1991). Bowers also argues for a non-content-area-specific learning approach that would emphasize the whole child and not just rote memorization.

In differentiating between the two methods of teaching, Bowers includes examples of behaviors that would occur during each educational experience. Representing constructivism, Bowers has combined the inductive thinking theory set forth by Taba, and the learning cycle, which began several years ago as part of the Science Curriculum Improvement Study (SCIS). Barnam (1989) has modified the terminology of the learning cycle to make it more meaningful for elementary school teachers. Representing the traditional or direct instruction approach, Bowers sites Ausubel's Advanced Organizer (1963). The following sets of behaviors are grouped as: 1. **Introductory**; the beginning of the daily lesson, 2.**Developmental**; the operationalizing of the lesson, and 3.**Culminating**; the summation of the daily lesson. I have combined Inductive thinking and Learning Cycle behaviors to represent the functions of a Constructivist classroom and The Advanced Organizer for the direct instruction classroom.

Bowers offers the following instructional model operationalizing direct instruction Bowers, 1991, p. 7).

Table 4

Operationalizing Direct Instruction

Introductory

*Clarify objectives
*Give examples
*Define context
*Prompt learner's prior knowledge and experience

Developmental

*Directed teaching
*Organization of tasks
*Logical order of material

Culminating

*Students integrate new learning and prior knowledge
*The teacher promotes logical and critical approach to information
*Students resolve conflicting information and misconceptions

(Bowers, 1991)

A paradigm describing traditional versus constructivist classroom environments is provided by de Esteban & Penrod (2000) (See Table 5).

Table 5

Traditional versus Constructivist Classroom Environment

Traditional Classroom	Constructivist Classroom
Curriculum is presented part to whole with emphasis in basic skills. Strict adherence to fixed curriculum is highly valued.	Curriculum is presented whole to part with emphasis on big concepts.
Curricular activities rely heavily on textbooks and notebooks.	Pursuit of student questions is highly valued.
Students are viewed as black slates onto which information is etched by the teacher.	Curricular activities rely heavily on primary sources of data and manipulative materials.
Teachers generally behave in a didactic manner, disseminating information to students.	Students are viewed as thinkers with emerging theories about the world.
Teachers seek the correct answer to validate students' learning.	Teachers generally behave in an Interactive manner mediating the environment for the students.
Assessment of student learning is viewed as separate from teaching and occur almost entirely through testing.	Teachers seek the students' points of view in order to understand students' present conceptions for use in subsequent lessons.
Students primarily work alone.	Assessment of student learning is interwoven with teaching and occurs through teacher observations of students at work and through students' exhibitions and portfolios

(de Esteban & Penrod, 2000).

CHAPTER III

METHODOLOGY

This chapter discusses the methodological and statistical procedures employed in this study. It examines the effects of constructivist versus traditional teaching methods on student achievement and comprehension in 8th grade physical science classes in a large, southeastern urban school system. Included in the chapter are explanations of the purpose and design of the research, setting description, population and sample, instrumentation, data collection, and analysis procedures.

Purpose and Design of the Study

Interest in middle school science achievement led the researcher to question whether the performance of 8th grade physical science students on the Virginia Standards of Learning Test and comprehension differed as a function of classroom orientation, namely teaching styles. There is little empirical research addressing the topic of teaching style and its effects on achievement in 8th grade science (How Schools Shortchange Girls: The AAUW Report, p. 55, Applefield et al, 2001).

The current study was designed to investigate the effectiveness of the constructivist method versus a more traditional method on achievement of 8th grade science students in an urban middle school district. Furthermore, this study also is designed to determine whether gender and race have an effect on outcomes as a function of teacher type. Thus, relationships among gender, ethnicity, and teacher types will be explored. This study will be of interest to urban universities preparing preservice teachers with methods necessary for implementation of constructivist practices. This chapter provides detailed

descriptions of the population to be studied, instruments used, data collection process, and data analyses.

This research is a causal-comparative study with three components or phases. There is no purposeful manipulation of the independent variables. Rather, the design determines whether pre-existing conditions are associated with differences on the measured variables (McMillan & Schumacher, 2001, p. 310). The purpose of this study is to investigate whether Standards of Learning (SOL) and Higher-Order Skills (HOS) scores vary as a function of type of teacher type (Constructivist, Mixed or Traditional), Gender (Male and Female) and Ethnicity (Caucasian and Minority).

Research Questions and Hypotheses

Problem Statement

This study will determine whether or not teacher type (constructivist, mixed or traditional) has an effect on achievement scores of 8th grade urban middle school students and whether performance differs by gender and ethnicity.

The research questions for this study include:

1. What teacher types characterize this sample of 8th grade science classes?
2. Do children who receive instruction in constructivist classrooms perform better on achievement and comprehension tests than children who receive instruction in traditional classrooms?
3. Is there a difference in achievement and comprehension outcomes as a function of gender and teacher type?

4. Is there a difference in achievement and comprehension outcomes as a function of ethnicity and teacher type?

There are six hypotheses in this study:

Hypothesis 1: There will be a difference in achievement by teacher type as measured by Standards of Learning science scores.

Hypothesis 2: There will be a difference in comprehension by teacher type as measured by Higher Order Skills scores.

Hypothesis 3: There will be a difference in achievement by gender and teacher type as measured by Standards of Learning scores.

Hypothesis 4: There will be a difference in comprehension by gender and teacher type as measured by Higher Order Skills scores.

Hypothesis 5: There will be a difference in achievement by ethnicity and teacher type as measured by Standards of Learning scores.

Hypothesis 6: There will be a difference in comprehension by ethnicity and teacher type as measured by Higher Order Skills scores.

Setting and Participants

Norfolk, Virginia maintains a population of 234,403 residents, including 113,358 Caucasians, 103,387 African-Americans, and 17,658 designated as other. Norfolk has 86,210 households, consisting of 51,915 families. Of those families, 36.9% consist of families headed by married couples, 18.8% headed by single mothers, and 30.2% consist of single people. Data reveal that 72.2% of all residents have graduated from high school, 16.8% from college, and that 5.8% hold a graduate degree.

The school system selected for this study is in Norfolk, Virginia, a large Southeastern Urban school district that educates over 37,000 students and is one of the largest in Virginia. Thirty-five elementary, eight middle and five senior high schools house a diverse ethnic and socio-economic group of students, including military dependents. Sixty percent of the student body qualifies for the free or reduced lunch program and the average cost per student annually is $6,662. The drop-out rate has steadily dropped to 3.3% by the year 2000. The school system has 8,000 PTA members, which make up the largest single organization in Norfolk. The city of Norfolk provides 83 million dollars per year in funding (34%), the state of Virginia provides 154 million dollars(63%), Federal funding is 4.5 million dollars (3%) and other is 2.5 million dollars(www.census.gov).

Participants and Sampling Design

The participants in this study consisted of students from urban middle schools in Norfolk, Virginia: Schools A through E. The sample included Caucasian and Minority students. A three-stage sampling design was employed. Table 6 provides data on the 8^{th} grade science students participating in this study.

Table 6

Participant Sample: Norfolk Public Schools 8th Grade Students

School	Population	Minority	Caucasian	Males	Females
School A	278	161	117	142	136
School B	290	218	82	136	154
School C	302	234	68	162	140
School D	341	140	161	174	414
School E	327	263	64	163	164

Note: Table reflects 8th grade students only.

Phase 1. The first stage consisted of sending out The Revised Constructivist Learning Environment Survey (CLES), (Taylor & Fraser, 1994) to every 8th grade science teacher in the Norfolk Public Schools district. Each middle school had two or three 8th grade science classes for a district total of 23. Three middle schools chose not to participate in the study, leaving five middle schools consisting of 13 teachers available as participants in the study. One teacher was a long-term substitute and not used. School E had only two 8th grade science teachers (see Table 7).

Table 7

Teacher Participation by School (8th Grade Science).

School	N
A	3
B	2
C	3
D	3
E	2

The CLES measures teacher perception of constructivist attributes in the learning environment, namely, their own classroom. This instrument is designed to enable researchers to measure the teachers' self-reported constructivist approaches and behaviors used in teaching science.

Phase 2. The CLES survey scores were used by the researcher to determine the extent to which classrooms are either traditional or constructivist. Traditional classrooms were those represented by low scores on the survey. Constructivist classrooms were those represented by high scores on the survey. From the five middle schools, five classrooms were chosen based on teacher scores on the CLES survey as constructivist, five as mixed and three as traditional. (Mixed teachers displayed traits of both constructivist and traditional teachers). The researcher then observed each classroom to ensure that each teacher was either constructivist, traditional, or mixed. This was accomplished by sitting in on classrooms in session for several hours a day. Notes were

taken from the observations, using the sub-scales from the CLES survey as a guide (See Appendix A for complete CLES survey).

Phase 3. Upon completion of the researcher observations, the teacher of each of the selected classes administered the 8th grade Virginia Standards of Learning tests to the students. A week later, the researcher administered the Higher-Order Skills measure to students as a follow-up to the Standard of Learning test. See Table 8 for student numbers and for sample sizes for each measurement.

Table 8

Descriptive Statistics for Teacher Type and Corresponding Sample Sizes for Each Dependent Variable: Standards of Learning (SOL) and Higher-Order Skills(HOS).

	SOL n	HOS n
Constructivist Teachers		
Teacher B,School A	25	18
Teacher B,School B	61	72
Teacher A,School C	67	0
Teacher B,School D	18	18
Teacher B, School E	11	11
Mixed Teachers		
Teacher A, School A	18	17
Teacher C, School A	9	9
Teacher C, School C	44	0
Teacher A, School D	73	18
Teacher A, School E	29	21
Traditional Teachers		
Teacher A, School B	29	0
Teacher A, School B	75	16
Teacher C, School D	25	17

Table 9 reports the self-assessment score from each teacher, and designated type. Type is designated as: T(traditional), C(constructivist), or M(Mixed) (See Appendix 1 for 30-item survey). The score distribution for each teacher was as follows:

Table 9

CLES (Constructivist Learning Environment Survey) Teacher Self-Assessment Survey Results.

		Self-Assessment	Type
School A:	Teacher A	109	M
	Teacher B	120	C
	Teacher C	112	M
School B:	Teacher A	91	T
	Teacher B	125	C
School C:	Teacher A	127	C
	Teacher B	93	T
	Teacher C	114	M
	Teacher B	123	C
	Teacher C	85	T
School E:	Teacher A	103	M
	Teacher B	117	C
	Overall Mean=	109.7	

Note: Type is designated as T(Traditional), M(Mixed), and C(Constructivist).

Table 10 provides information pertaining to Teacher Type and Socio-Economic standing as they pertain to each school. Results reveal that constructivist, mixed and traditional teachers were dispersed evenly among schools. Socio-economic status was determined by ranking the schools according to percentages of free and reduced lunches as published by the Virginia Department of Education website (www.pen.k12.va.us/VDOE/Finance/Nutrition/snp2000school.pdf).

Table 10

Matrix of Teacher Type (TT) and Socio-Economic Status (SES) for each School.

	TT			SES(H,M,L)
School	C	M	T	
A	Teacher B	Teacher A Teacher C		H
B	Teacher B		Teacher A	L
C	Teacher A	Teacher C	Teacher B	L
D	Teacher B	Teacher A	Teacher C	M
E	Teacher B	Teacher A		M

Note: (TT)C=Constructivist, M=Mixed, T=Traditional. (SES)H=High, M=Middle, L=Low.

Table 11 reflects years of teaching experience for each participating teacher. Table 11 shows that constructivist teachers had 8, 1, 2 and 34 years teaching experience, mixed teachers had 36, 10, 30 and 1years teaching experience, and that traditional teachers had 11, 1, and 10 years experience (one constructivist and one mixed teacher had no data

available pertaining to years teaching experience); indicating that years teaching experience were similar over the teaching type categories.

Table 11

Years Teaching Experience for Participating Teachers

School	Teacher	Years Teaching Experience
A	A	10
	B	34
	C	30
B	A	10
	B	2
C	A	8
	B	11
	C	36
D	A	*
	B	1
	C	1
E	A	1
	B	*

*= Indicates that no information on those teachers was available.

In order to control for as many pre-study differences as possible, Tables 10 and Table 11 data reflect that socio-economic status and years teaching experience are similar across constructivist, mixed and traditional teachers, thus negating these variables as reasons for confounding outcomes.

Differences between classrooms also were minimized by the distribution of different teacher types among the five middle schools. There was a least one constructivist teacher in each school and for each socio-economic status. All teachers in all of the five middle schools taught racially mixed, heterogeneous classrooms.

Instrumentation

In this section the dependent or measured variables are described. They include:

CLES: The Revised Constructivist Learning Environment Survey (Taylor & Fraser, 1994). The Revised Constructivist Learning Environment Survey is a 30-item questionnaire entitled "What happens in my science classroom". It identifies teacher perceptions of the presence of characteristics of constructivism on five subscales, with six questions each (see Appendix 1). The subscales are as follows:

Personal Relevance- This subscale included questions one through six, and determined whether students could make connections between science class and their worlds outside of school, or how relevant science class was to real life.

Scientific Uncertainty- This subscale included questions seven through twelve, and concerned the history and development of science, scientific principles, values, and the nature of scientific inquiry. Teachers determined whether or not their students could make connections between modern and historical science, and the changes in science over time.

Critical Voice- This subscale included questions thirteen through eighteen, and explored questioning techniques by the students, do students feel safe to ask questions and to explore ideas in class, and can they express their opinions and feel ownership in the class through participation?

Shared Control- This subscale included questions nineteen through twenty-four, and addressed student participation in terms of shared responsibility for their own learning. The questions determined whether or not students had a say in what activities they chose, alternative forms of assessment, and a sense of autonomy in the classroom through freedom to make choices.

Student Negotiation- This subscale included questions twenty-five through thirty and addressed cooperative and group learning, and the degrees to which students could interact and speak to each other in the classroom as a function of learning.

Teachers were asked to rate each statement on a 5 point Likert rating scale: (1) "almost never" (2) "seldom" (3) "sometimes" (4) "often", and: (5) "almost always". The composite scores range from a "low" (score of 30) or "high" (score of 150) degree of constructivism in the classroom environment. Therefore, highest scores represented more constructivist classrooms, and the lowest scores represented the more traditional classrooms.

Previous studies have examined the reliability and validity of the Revised Science CLES. The results were presented at the National Educational Research Association meeting in April of 1995 (Taylor, Dawson & Fraser, 1995). The CLES was found to be valid and reliable in its statistical characteristics through a collaboration of two large-scale studies of classroom learning environments in Australia (Taylor, Dawson, & Fraser,

1995) and in the USA (Dryden & Fraser, 1998), involving two Grade 10 science classes and 2,494 randomly selected 8th and 9th grade students. Completed questionnaires of 494 students in 41 classrooms from 13 schools were analyzed. The data were subjected to statistical item analysis using the individual student as the unit of analysis. The Chronbach alpha reliability coefficients which provide a measure of the internal consistency of each of the five CLES subscales, were all in excess of .70 indicating a satisfactory degree of internal consistency for this measure (Fraser, 1986). Specifically, internal consistency for Personal Relevance was .82, Scientific Uncertainty .72, Critical Voice .88, Shared Control .91 and Student Negotiation .89 (Taylor, Dawson & Fraser, 1995).

Standards of Learning Test for 8th Grade Science. The Standards of Learning tests for the state of Virginia are standardized, cumulative end of the year tests given in grades three, five, and eight and for each core subject in high school. They measure if the standards of learning for each grade and subject area have been mastered by the students. In 1995, after the Virginia Board of Education adopted new Standards of Learning (SOL), the Virginia Department of Education (VDOE), in collaboration with hundreds of educators across Virginia including teachers, administrators and content specialists, and Harcourt Educational Measurement, developed a series of tests to measure student achievement against the standards (See Appendix C).

Field tests of the SOL assessments were conducted in Spring of 1997 to a sample of students across Virginia. Reliability was estimated by employing the Kuder-Richardson internal consistency reliability coefficient and an inter-rater reliability assessment, which consisted of two independent raters. The Kuder-Richardson coefficient was .84. When

the two raters assigned the same score to a student's paper, they were in "exact agreement", while scores differing by two or more points were "non-adjacent". Inter-rater reliability was .85 (Virginia Standards of Learning Assessment Technical Report, 2000, p. 25, 31).

Criterion validity was described by the Virginia Department of Education's interpretative report: "In content areas and grade levels where there were reasonable matches of content between the Standards of Learning test, the Stanford 9 and the LPT…"(t)hese data show a strong relationship between the relative standing of Virginia's schools on the SOL tests and both the Stanford 9 and the LPT" (1998, p.26), with the correlation coefficient r being .73 (Virginia Standards of Learning Assessment Technical Report, 2000, p. 30).

Higher-Order Skills Measurement. A researcher-developed instrument for comprehension of higher-order skills was written using Virginia's Standards of Learning Test to measure item comprehension. This was accomplished by obtaining items as supplied by the 8th grade physical science Standards of Learning test and expanding on the multiple choice format for each item from simply selecting a,b,c,or d, to a short answer/essay format.

Items were chosen from the Virginia's Standards of Learning Test administered in Spring 2,000, which contained 50 items, 18 pertaining to 6th grade content, 20 pertaining to 7th grade content, and 12 pertaining to 8th grade content. From these 50 items, the researcher chose 7 items from the set of 6th grade content items (a survey of physical, life and earth sciences), 7 from the set of 7th grade content items (life science), and 10 from

the set of 8th grade items (physical science) (See Appendix B for complete Higher-Order Skills test).

Items were identical to the Standards of Learning items, except that in addition to being required to circle the correct answer as in the regular multiple-choice format, students also were asked to explain their answer. At this point, comparison was made between the scores from the SOLs and the Higher-Order Skills measurement. The Higher-Order Skills instrument measured comprehension. Comprehension, according to Bloom (1956) refers to the type of understanding such that the individual knows what is being communicated and can make use of the material or apply the idea. Comprehension enables translation such that the material in its original communication is preserved although the form of the communication has been altered, as in transferring multiple-choice answers into short-essay format. Comprehension is also the ability to understand non-literal statements and to interpret and extrapolate (Bloom, 1956, pp. 204,205). In short, the Higher-Order Skills instrument asked the students to explain and extrapolate their multiple-choice answer.

Validity was established by a peer review of the test for content and face validity, and construct validity. The four peer reviewers found the Higher-Order Skills test to possess content validity in that the instrument was found to measure the entire content of the Standards of Learning test. Convergent construct validity was inherent in the design of the Higher-Order Skills test as it was written directly from the Standards of Learning test, asking, in effect, the same questions but requiring explanations, resulting in a moderate correlation when exposed to statistical analysis (.190). Inter-rater reliability among the

four peer reviewers resulted in an average mean relationship of .85, indicating high inter-rater reliability.

Procedure

Phase 1. Middle-school principals were contacted for consent. Principals were sent consent letters (see Appendix E) for them to sign and return. Upon obtaining consent from five of the eight principals, The Revised Constructivist Learning Environment Survey (CLES) (Taylor & Fraser, 1994) was delivered to 8th grade physical science teachers in those schools, along with teacher consent forms to sign and return (see Appendix D). The population consisted of 13 teachers.

Phase 2. The CLES survey scores were used by the researcher to determine which classrooms were traditional and which were constructivist. From the five middle schools, thirteen teachers were available and sent in self-scored CLES surveys. The researcher observed for teaching styles and extensive notes were completed for each teacher (See chapter 4).

Researcher observations were conducted over a period of 4 weeks. The researcher observed each classroom for a period of approximately 3 hours. Extensive notes were taken and analyzed for evidence of constructivist practices and classroom setting. Each of the five CLES survey subscales was employed as an observation guide. The subscales were examined in context of each classroom as follows:

1. Personal Relevance- each classroom was observed for the degree to which the teacher showed relevance between the content and students' lives. This was measured through observing physical classroom displays of science news from various news sources locally and throughout the world, through observing how

the teacher discussed content in context to world events and applications to real world situations, and through observing discussions between students and teacher to determine if prior knowledge of students was incorporated into classroom discussion.

2. Scientific Uncertainty- each classroom was observed to determine whether or not students experienced the inherent uncertainty and limitations of scientific knowledge. Observations were made also to assess the extent to which opportunities were provided for students to experience scientific knowledge as arising from theory-dependent inquiry, involving human experience and values, and culturally and socially determined. The development of scientific theories over time and the evolutionary quality of scientific knowledge was observed.
3. Critical Voice- observations were made to determine if student empowerment was fostered by allowing students' critical attitudes towards the teaching and learning activities. The extent to which a social climate had been established in which students felt that it was legitimate and beneficial to question the teacher's pedagogical plans and methods, and to express concerns about any impediments to their learning was measured.
4. Shared Control- observations were made to determine whether or not students were allowed opportunities to develop as autonomous learners. Were there opportunities for students to exercise a degree of control over their learning that extended beyond the traditional practice or working 'independently' in class on teacher-prescribed problems? Were students invited to share control with the teacher of the learning environment, including the articulation of their learning

goals, the design and management of their activities, and assessment criteria? Were there portfolios placing emphasis on students evaluating their own conceptual development?

5. Student Negotiation- observations were made to determine whether or not opportunities existed for students to explain and justify to other students their newly developing ideas, to listen and reflect on the viability of other students' ideas, and to reflect self-critically on the viability of their own ideas. Were students actively engaging in their own knowledge acquisition?

Employing the subscales of the CLES survey as a guide, the researcher through observation, determined whether or not the classroom environments were indeed either constructivist, traditional or mixed. The researcher noted where certain behaviors from the subscales were present or absent in each classroom, then ranked the 13 teachers from most constructivist to most traditional. The lowest scores represented the traditional classrooms, and the highest scores represented the constructivist classrooms.

Phase 3. Upon researcher observation of the classes, the researcher distributed copies of the Higher-Order Skills test to each teacher with directions to administer a week after the Standards of Learning test. Standards of Learning scores were obtained by contacting each school for a viewing of the printout of the results. The answers of the SOL tests and the comprehension measurement were compared to determine if comprehension is greater with those students taught in the constructivist classrooms versus the traditional classrooms.

Data Analysis

Phase 1. Descriptive results from CLES drawn from the five middle schools were analyzed by the researcher through scoring the CLES and determining an initial categorization between constructivist, traditional, and mixed classrooms.

Phase 2. In addition to the teacher-scored CLES instrument, descriptive results from the observation of classrooms to determine if the classrooms were indeed either traditional, constructivist or mixed were analyzed through analysis of extensive coded notes taken during observation and employing the five subscales of the CLES as an observation guide for interpretation. Each of the five subscales along with constructivist traits is included in Table 12 (See Table 12):

Table 12

Constructivist Traits Associated with CLES Subscales

Subscale	Trait
Personal Relevance	1. Physical classroom displays of news articles and stories. 2. Observing techniques of teacher questioning and discussion patterns based on higher levels of Bloom's taxonomy (evaluation, synthesis). 3. Determining if application of students' prior knowledge was employed.
Scientific Uncertainty	4. Determining if opportunities were provided for students to experience scientific knowledge arising from theory-dependent inquiry and experimentation. 5. Determining whether or not human experiences and values, both culturally and socially determined were incorporated into the classroom. 6. Demonstration of appreciation of the evolutionary aspect of scientific knowledge.
Critical Voice	7. Observing whether or not student empowerment was fostered by allowing students' critical thinking and attitudes towards the teaching and learning activities. 8. Determining whether or not students were allowed to express concerns about any impediments to their learning.
Shared Control	9. Determining whether or not opportunities were given students to exercise a degree of control over their learning environment by articulating their goals, and exerting some degree of control over management of their own activities. 10. Determining whether assessment tools were in place that enabled students to evaluate their own conceptual development.

Table 12 (con't).

Constructivist Traits Associated with CLES Subscales

Subscale	Trait
Student Negotiation	
	11. Determining whether opportunities were given for students to explain and justify their ideas and conceptual development. 12. Determining whether or not students displayed active engagement of their own knowledge acquisition.

Teachers were deemed constructivist if they exhibited at least 7 of these traits from each of the five subscales taken from the CLES instrument. Mixed teachers were those that possessed at least 5 of the qualities mentioned above, while traditional teachers were those that possessed 4 or fewer of the qualities. As a result, final determination of classrooms as either constructivist, traditional or mixed were made.

Phase 3. The quantitative data from the study was analyzed using Multivariate Analysis of Variance (MANOVA). It was used to analyze data to determine differences in achievement and comprehension scores associated with the different teaching methods, gender and ethnicity.

The Independent variables were:

1. Teacher type (with three levels: constructivist, mixed and traditional).
2. Gender (with two levels: male vs. female).
3. Ethnicity (with two levels: Minority vs. Caucasian).

The Dependent variables were:

1. Standards of Learning 8th grade physical science scores.
2. Comprehension measurement (Higher-Order Skills scores).

Multivariate Analysis of Variance allows the researcher to examine multiple comparisons. It allows the examination of main effects and interactions of independent variables on the composite dependent variable. MANOVA also allows the researcher to make multiple comparisons while maintaining a constant alpha level (.05 or .01), thus reducing the chance of Type 1 Error associated with conducting multiple Univariate Analysis of Variance tests. Type 1 Error refers to the misinterpretation of data in which the researcher believes there is a difference caused by the treatment, but there is not.

CHAPTER IV

RESULTS

The goal of this study was to determine if constructivist teaching pedagogy affected outcomes on two achievement measures when compared to traditional teaching pedagogy. The Virginia Standards of Learning test was chosen as the instrument to measure overall achievement, and the Higher Order Skills test was developed to measure comprehension, which is a component of achievement (Bloom, 1956).

This study sought to determine whether or not teacher type (constructivist vs. traditional) had an effect on achievement scores of 8th grade urban middle school students and whether performance differs by gender and ethnicity.

The research questions for this study include:

1. What teacher type characterizes this sample of 8th grade science classes?
2. Do children who receive instruction in constructivist classrooms perform better on achievement and comprehension tests than children who receive instruction in traditional classrooms?
3. Is there a difference in achievement and comprehension outcomes as a function of gender and teaching styles?
4. Is there a difference in achievement and comprehension outcomes as a function of ethnicity and teaching styles?

Beyond the general research questions of what types of classroom orientations characterize these middle school science classes, the following hypotheses were tested:

> Hypothesis 1: There will be a difference in achievement by teacher type as measured by Standards of Learning science scores.

Hypothesis 2: There will be a difference in comprehension by teacher type as measured by Higher-Order Skills scores.

Hypothesis 3: There will be a difference in achievement by gender and teacher type as measured by Standards of Learning scores.

Hypothesis 4: There will be a difference in comprehension by gender and teacher type as measured by Higher-Order Skills scores.

Hypothesis 5: There will be a difference in achievement by ethnicity and teacher type as measured by Standards of Learning scores.

Hypothesis 6: There will be a difference in comprehension by ethnicity and teacher type as measured by Higher-Order Skills scores.

Chapter four is divided into two parts. Part one provides the results for the analysis of data gathered through the CLES survey regarding teacher self-assessment, and also includes observational data. Part two provides the results for the analysis of data from the Standards of Learning test for 8th grade science, and the Higher-Order Skills assessment.

Results of Quantitative Analysis of Data Gathered from CLES survey.

The Constructivist Learning Environment Survey (CLES) teacher self-assessment had a possible score range of 30 to 150. Low scores represented more traditional teachers, while higher scores represented more constructivist teachers (see Table 9).

Using the data collected from the CLES survey, the initial procedure was to determine which teachers were constructivist, mixed, or traditional. Self-assessment scores were augmented with designations derived from observations, and a determination for teacher type was made (See Chapter 3). Scores ranged from a low of 86 to a high of

125. The cut-off for each designation was 125-117 (constructivist), 110-106 (mixed) and 89-86 (traditional). Results showed that of the thirteen teachers participating in the study, five were classified as constructivist, five as mixed, and three as traditional. Teachers classified as mixed exhibited behaviors of both traditional and constructivist teachers, for example, answering many questions in the middle range of the scoring rubric.

In order to examine whether constructivist teaching practices contributed to higher comprehension on 8th grade science tests, teaching styles had to be determined for the 13 teachers participating in this study. The teachers were analyzed, first with a self-assessment survey (CLES) and then with researcher observations. Descriptive statistics for items on the CLES survey are given by teacher type, Constructivist (C), Mixed (M) and Traditional (T) (see Appendix F). Means and Standard Deviations for each of the subscales are given (see Table 13).

Table 13

Descriptive Statistics for CLES Subscales by Teacher Type(T.T.): Constructivist (C), Mixed (M), and Traditional (T).

	T.T.	M	N	SD
Personal Relevance				
	C	4.00	5	.73394
	M	3.26	5	1.03280
	T	3.055	3	.85423
Scientific Uncertainty				
	C	3.9	5	.57619
	M	3.23	5	.36697
	T	3.3	3	.49586
Critical Voice				
	C	4.5	5	.27568
	M	4.26	5	.56095
	T	3.16	3	.34898
Shared Control				
	C	3.76	5	.29439
	M	3.4	5	.28284
	T	2.38	3	.39035
Student Negotiation				
	C	4.23	5	.26583
	M	3.93	5	.39328
	T	3.165	3	.46068
Total	C	4.083	5	.517343
	M	3.01500	5	.599889
	T	3.6200	3	.689528

Note: Personal Relevance refers to items (1-6), Scientific Uncertainty (7-12), Critical Voice (13-18), Shared Control (19-24), and Student Negotiation (25-30).

Table 13 reveals that constructivist teachers reported the highest mean scores for each subscale, indicating that they scored higher on each CLES subscale than either mixed or traditional teachers. Only in the Scientific Uncertainty subscale did traditional teachers score a higher mean than mixed teachers, indicating that more traditional teachers emphasized the historical nature of science and the changes of science over time than did mixed teachers.

An analysis of each CLES subscale as it pertains to how each teacher type scored and some examples of behaviors for each teacher type pertaining to subscale follows:

Personal Relevance

Each classroom was observed for the degree to which the teacher showed relevance between the content and students' lives. This was measured through observing physical classroom displays of science news from various news sources locally and throughout the world, through observing how the teacher discussed content in context to world events and applications to real world situations, and through observing discussions between students and teacher to determine if prior knowledge of students was incorporated into classroom discussion.

On the CLES, constructivist teachers averaged a 4.0 on a scale from 1 to 5, indicating high levels of these proficiencies, which include connecting the students' lives to the world outside of school. Constructivist teachers tended to display almost all of the Personal Relevance traits. For example, Teacher A from School C displayed news articles and stories on the bulletin boards and frequently discussed world events in light of the review game that was being played in order to prepare for the Standards of Learning test. Questioning and discussion techniques employed higher levels of Bloom's

taxonomy and open-ended questions. The students were responsible for explaining their answers when called on, and were allowed to disagree with the teacher's answers. Application of prior knowledge was employed as the teacher asked the students what they already know of the topic they were discussing.

Mixed teachers averaged 3.3, somewhat lower that constructivist teachers, indicating a more traditional pedagogy although mixed with some constructivist philosophies. Mixed teachers displayed some Personal Relevance traits. Teacher C from School C displayed current events on one of her bulletin boards. Higher level questions were asked by the teacher while students were allowed to interact with each other before answering the questions, although students were not allowed to question the teacher's answers.

Traditional teachers averaged 3.1, indicating not much connection with the students' world outside of school. Traditional teachers displayed almost no personal relevance traits. Teacher B from School C had students working in groups, but no questions were being asked by the students, they instead were looking up the answers to the questions from the book, which is a very low level "questioning" strategy. In none of the traditional classrooms were high level questions asked.

Scientific Uncertainty

Each classroom was observed to determine whether or not students experienced the inherent uncertainty and limitations of scientific knowledge. Observations were made also to assess the extent to which opportunities were provided for students to experience scientific knowledge as arising from theory-dependent inquiry, involving human experience and values, and culturally and socially determined. The development of

scientific theories over time and the evolutionary quality of scientific knowledge was observed.

Constructivist teachers averaged a score of 3.9, indicating that the nature of science, with it's evolutionary nature and refinement over time, was part of their students' learning experience in the classroom. Constructivist teachers displayed most of the Scientific Uncertainty traits in their classrooms. Teacher A from School C had prior laboratory work hanging from the bulletin boards, as well as lab equipment in view that was in various stages of an experiment. During a discussion about middle-eastern oil fields, this teacher asked the students to place themselves in the Saudi's place during their discussion, thereby allowing the students to experience cultural values different than their own. All of the constructivist teachers had evidence of past or current experiments and labs in various stages of completion. In one constructivist teacher's classroom, a hydroponic plant center equipped with a traveling sunlamp and an aquarium of fish was in constant charge of the students.

Mixed teachers averaged 3.2, a somewhat lower score. All of the mixed teachers had lab and experimental work displayed. However, most did not stress the evolutionary aspect of science. Teacher C from School C displayed her labs in the back of the room, and her students were held responsible for a community project requiring them to distribute fliers to their neighborhoods, showing interest in social values. Teacher A from School A also displayed labs in her classroom along with scientific research investigations that were displayed on standing boards.

Traditional teachers averaged a slightly higher mean of 3.3, indicating a marginally higher survey scoring in this subscale. The only trait from Scientific Uncertainty that the

traditional teachers possessed was that all three of them had prior lab work displayed in their classrooms. In Norfolk Public Schools, science teachers are required to conduct labs as part of their jobs.

Critical Voice

Observations were made to determine if student empowerment was fostered by allowing students' critical attitudes towards the teaching and learning activities. The extent to which a social climate had been established in which students felt that it was legitimate and beneficial to question the teacher's pedagogical plans and methods, and to express concerns about any impediments to their learning was measured.

Constructivist teachers scored a mean of 4.5, very high out of a possible 5, indicating that students were empowered to question teaching and learning activities, and to have an active role in their own learning. Teacher A from School C allowed students to be vocal about their concerns and interests, thereby exercising a degree of control over their learning environment. Student empowerment was evidenced through the classroom climate, tone of discussion and critical thinking. Teacher B from School B also gave students the opportunity to express concerns about their work. They also were allowed to choose their discussion partners, thereby exercising some degree of control over their learning environment. Teacher B from School D allowed his students to ask questions of him in a critical sense.

Mixed teachers scored somewhat lower with 4.3, which indicates an almost middle range response to this subscale. Teacher A from School A displayed two of the Critical Voice traits, including allowing students to express concerns through questions, which were answered at a high level. Students also were given opportunities to explain and

justify their answers, even if the teacher corrected their misconceptions. Teacher A from School E also allowed her students to express concerns about misunderstandings, which were met in a reasonable way by the teacher, who tried to address their concerns.

Traditional teachers averaged 3.2, much lower than mixed teachers, indicating that students in traditional teachers' classes were not given the opportunity to participate in the management and control of the classroom activities and learning. The only Critical Voice trait displayed by a traditional teacher was by Teacher B from School C, who allowed students to express concerns about their misunderstandings, and told them to look up the answers and did not address them herself.

Shared Control

Observations were made to determine whether or not students were allowed opportunities to develop as autonomous learners. Were there opportunities for students to exercise a degree of control over their learning that extended beyond the traditional practice or working 'independently' in class on teacher-prescribed problems? Were students invited to share control with the teacher of the learning environment, including the articulation of their learning goals, the design and management of their activities, and assessment criteria? Were there portfolios placing emphasis on students evaluating their own conceptual development?

Constructivist teachers scored an average mean of 3.8, indicating a higher than average score for student control, including presence of portfolios, or other means to self-assess their learning. All of the constructivist teachers employed portfolios or rubrics as part of their assessment strategies. Teacher A from School C required the students themselves to be responsible for their own portfolios, as did most of the

constructivist teachers. Students were allowed to choose their discussion partners during discussion of a film. Teacher B from School A allowed her students to choose among four labs, of which two had to be completed by a certain time frame.

Mixed teachers averaged 3.4, in the middle range of this subscale. Most of the mixed teachers had portfolios on display in their classrooms, which tended to be the only Shared Control trait for most of the traditional teachers. Teacher C from School A also attached rubrics to the students' labs, indicating a self-assessment on part of the student, with the teacher checking behind to ensure proper grading. Portfolios were also on display in the back of the room.

Traditional teachers averaged 2.4, indicating a low degree of student-directed activities and self-assessment. All three traditional teachers displayed portfolios in their classrooms, which was the only Shared Control trait demonstrated.

<u>Student Negotiation</u>

Observations were made to determine whether or not opportunities existed for students to explain and justify to other students their newly developing ideas, to listen and reflect on the viability of other students' ideas, and to reflect self-critically on the viability of their own ideas. Were students actively engaging in their own knowledge acquisition?

Constructivist teachers scored an average mean of 4.2, indicating a high degree of student-to-student interaction and vocalization to each other and to the teacher in the form of questioning, verifying, and problem solving. All constructivist teachers allowed their students to be active instead of passive learners through working cooperatively and through student-to-student discussion techniques, allowing

engagement of their own knowledge acquisition. Teacher A from School C gave students several opportunities to explain and justify their ideas, and to also actively engage in their own knowledge acquisition by working in groups. Almost all of the constructivist teachers displayed both of the Student Negotiation traits.

Mixed teachers averaged 3.9, indicating a higher than average amount of student interaction. Four of the five mixed teachers displayed the Student Negotiation trait of allowing their students to actively engage in their own knowledge acquisition through various techniques. Teacher A from School A also allowed students to explain and justify their answers. Teacher A from School E also allowed her students to explain their answers, although the teacher did not allow differing opinions.

Traditional teachers averaged 3.2, indicating an average amount of student interaction and cooperative learning situations. Only one of the traditional teachers displayed active engagement on part of the students, through discussion techniques. Teacher A from School B did not allow her students to speak to each other.

Analysis and Results of Quantitative data by Hypotheses.

One Multivariate Analysis of Variance (MANOVA) was employed to test all six Hypotheses (see table 14). The Omnibus MANOVA test (Pillai's Trace) was statistically significant (See Table 14), therefore, follow-up univariate Analysis of Variance tests were conducted. Main effects and interaction effects were examined for teacher type (constructivist, mixed or traditional), gender (male, female), and ethnicity (Caucasian, Minority) on both measurement instruments; the Standards of Learning 8th grade science test, and the Higher-Order Skills test. This analysis was performed to determine if

teacher type affected outcomes and if gender and ethnicity would interact significantly with teacher type. Table 14 includes results from the Multivariate Analysis of Variance.

Table14

Multivariate Analysis of Variance between Teacher Type(TT), Gender(G) and Ethnicity(E) (Independent Variables) and Standards of Learning(SOL) and Higher-Order Skills(HOS) (Dependent Variables): Tests of Between-Subjects Effects.

Source	Pillai's Trace	F		df	p
Intercept	.991	.9016		2	.000
TT	.068	SOL	.829	2	.483
		HOS	5.699	2	.004*
G	.095	SOL	5.705	2	.004*
		HOS	3.479	2	.033**
E	.031	SOL	1.311	2	.272
		HOS	1.396	2	.250
TT x G	.012	SOL	.058	1	.809
		HOS	2.022	1	.157
TT x E	.023	SOL	.408	1	.524
		HOS	3.898	1	.050**
G x E	.027	SOL	.807	2	.448
		HOS	1.797	2	.169
TT x G x E	.009	SOL	1.294	1	.257
		HOS	.299	1	.585

Note: *p <.01
**p <.05

Hypothesis 1: *There will be a difference in achievement by teacher type as measured by SOL science scores.*

The first hypothesis examined the degree to which constructivist vs. traditional teaching (teacher type) affected science achievement outcomes. As shown in table 14, results from the Multivariate Analysis of Variance revealed no statistically significant main effect between Teacher Type and Standards of Learning scores (See Table 14). Table 15 provides the means and standard deviations for Teacher Type as independent variable and Standards of Learning as the dependent variable. The use of the Mean as a measure of central tendency revealed that the teachers classified as Constructivist had a slightly higher mean on the Standards of Learning exam (see Table 15).

Table 15

Descriptive Statistics for Dependent Variable by Teacher Type (T.T.): Standards of Learning Score

T.T.	Mean	SD	n
C	434.24	43.75	113
M	428.42	39.98	128
T	426.37	43.07	100
Total	429.75	42.17	341

Note: Score range = (0 – 600). C=Constructivist, M=Mixed, T=Traditional.

Hypothesis 2: *There will be a difference in comprehension by teacher type as measured by Higher Order Skills scores.*

The second hypothesis investigated the degree to which constructivist vs. traditional teacher types affected science comprehension outcomes. Results from the Multivariate Analysis of Variance report a statistically significant main effect between Teacher Type and Higher-Order Skills scores $F(2,185)=5.699$, $p>.01$ (see Table 14), indicating that teacher pedagogy influenced comprehension test outcomes. Traditional teacher type scored the highest overall mean, and constructivist teachers scored the lowest mean (see Table 16).

Table 16

Descriptive Statistics for Dependent Variable by Teacher Type(T.T.): Higher-Order Skills Scores

T.T.	Mean	SD	n
C	36.56	25.93	79
M	43.81	28.83	73
T	49.18	18.95	33
Total	41.67	26.38	185

Note: Score range = (0 – 100). C=Constructivist, M=Mixed, T=Traditional.

Descriptive statistics for each teacher and the corresponding n's are as follows (see Table 17).

Hypothesis 3: *There will be a difference in achievement by gender and teacher type as measured by SOL scores.*

Results from the Multivariate Analysis of Variance report no statistically significant interaction effect between gender and teacher type on Standards of Learning scores (see Table 14), indicating that teacher type and gender did not interact to influence Standards of Learning scores.

Table 17 provides descriptive statistics for Gender and Teacher Type as independent variables and Standards of Learning as dependent variable.

Table 17

Means and Standard Deviations for Gender(Male and Female) and Teacher Type (Constructivist, Mixed and Traditional) as Independent Variables and Standards of Learning as Dependent Variable.

Teacher Type	Gender	M	SD	n
C				
	F	460	47	21
	M	461	69	13
M				
	F	457	30	25
	M	457	35	21
T				
	Total	426	43	100

Note: Score range =(0-600). Traditional students were not designated by gender.

C=Constructivist, M=Mixed, T=Traditional.

Hypothesis 4: *There will be a difference in comprehension by gender and teacher type as measured by Higher Order Skills scores.*

Results from the Multivariate Analysis of Variance report no significant interaction effect at the .05 level. (see Table 14) for gender and Higher Order Skills scores,

indicating that gender was not influenced by H.O.S. outcomes as a function of teacher type.

Table 18 provides descriptive statistics for Gender and Teacher Type as independent variables and Higher-Order Skills as dependent variable, showing females with a higher mean for Higher-Order Skills measurement, though not statistically significant. Standard Deviation showed lower variation with females.

Table 18

Means and Standard Deviations for Gender (Male and Female) and Teacher Type (Constructivist, Mixed and Traditional) as Independent Variables and Higher-Order Skills as Dependent Variable.

Teacher Type	Gender	M	SD	n
C				
	F	49.43	29.09	21
	M	27.00	24.46	13
M				
	F	53.64	30.44	25
	M	48.57	30.78	21
T				
	Total	49.18	18.95	33

Note: Score range = (0-100). Traditional students were not designated by gender.

C=Contructivist, M=Mixed, T=Traditional.

Hypothesis 5: *There will be a difference in achievement by ethnicity and teacher type as measured by SOL scores.*

Results from the Multivariate Analysis of Variance report no significant difference between ethnicity and Standards of Learning scores (see Table 14) as a function of an interaction with teacher type.

Table 19 provides descriptive statistics for Ethnicity and Teacher Type as independent variables and Standards of Learning as dependent variable, showing the mean for Caucasians as highest with Standards of Learning as dependent variable.

Table 19

Means and Standard Deviations for Ethnicity(Minority and Caucasian) and Teacher Type (Constructivist, Mixed and Traditional) as Independent Variables and Standards of Learning as Dependent Variable.

Teacher Type	Ethnicity	M	SD	n
C				
	Minority	447	53	28
	Caucasian	470	31	24
M				
	Minority	450	31	29
	Caucasian	470	31	17
T				
	Total	426	43	100

Note: Score range =(0-600). Traditional students were not designated by ethnicity. C=Constructivist, M=Mixed, T=Traditional.

Hypothesis 6: *There will be a difference in comprehension by ethnicity and teacher type as measured by Higher Order Skills scores.*

Results from the Multivariate Analysis of Variance report a significant interaction effect between Teacher Type and ethnicity on Higher-Order Skills scores,

F(2,185)=3.898, p>.05, indicating that there is a difference in comprehension scores as a function of teacher styles and ethnicity (see Table 14).

Table 20 provides descriptive statistics for Ethnicity and Teacher Type as independent variables and Higher-Order Skills as dependent variable, showing the mean for Caucasian students with mixed teachers as having the highest mean.

Table 20

Means and Standard Deviations for Ethnicity(Minority and Caucasian) and Teacher Type (Constructivist, Mixed and Traditional) as Independent Variables and Higher-Order Skills as Dependent Variable.

Teacher Type	Ethnicity	M	SD	n
C				
	Minority	41	29	28
	Caucasian	29	25	24
M				
	Minority	45	29	29
	Caucasian	62	30	17
T				
	Total	49	19	33

Note: Score range =(0-100). Traditional students were not designated by ethnicity. C=Constructivist, M=Mixed, T=Traditional.

Figure 2 represents the means of Higher Order Skills Scores and interaction of teacher type and ethnicity (see Figure 2). In Figure 2, for Higher-Order Skills scores, Caucasians scored higher with mixed teachers than with constructivist teachers. Minorities had higher scores with constructivist teachers and lower scores with mixed teachers.

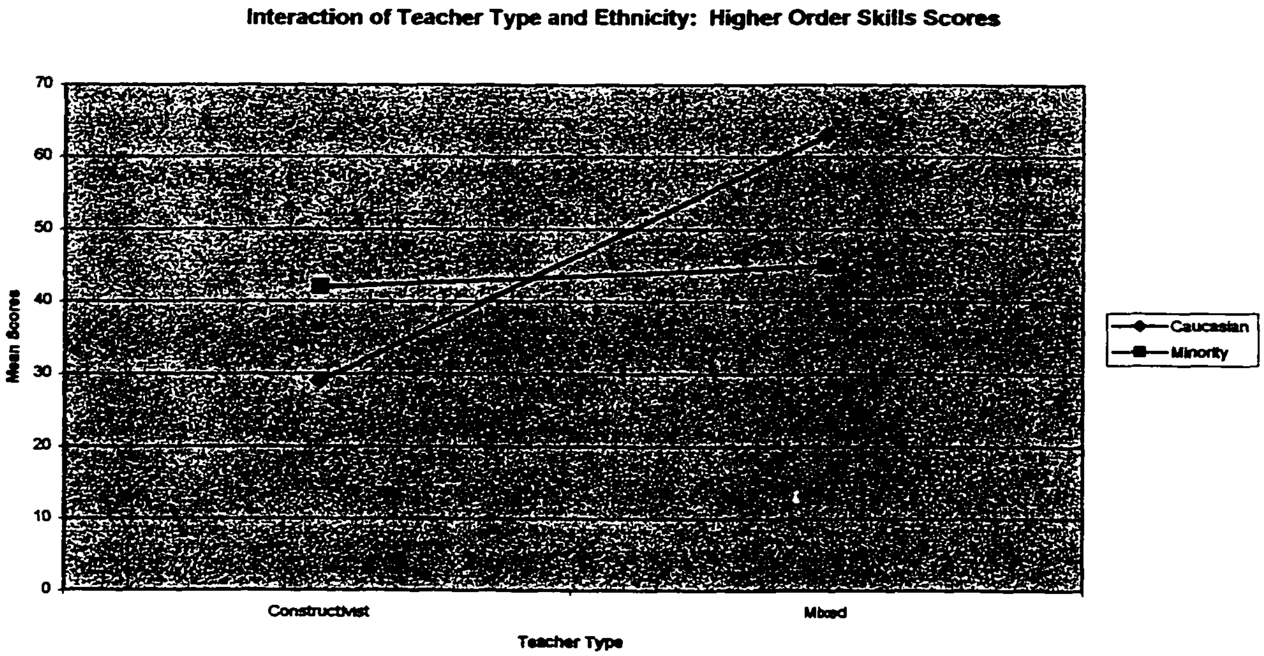

Figure 2. Interaction of Teacher Type and Ethnicity: Higher-Order Skills Scores

Note: Figure 2 excludes traditional teacher type because gender and ethnicity were not recorded by traditional teachers. Descriptive statistics were utilized to determine where the specific differences in outcomes were. Appendix G provides a full analysis of the dependent measures by interactions of teacher type, gender and ethnicity (see Appendix G).

Summary of Analysis of Data

The statistical analysis presented in this chapter provided an interpretation of the data relative to each of the hypotheses. To examine whether constructivist teaching practices contributed to higher comprehension on 8^{th} grade science tests, teaching styles of 13 participating teachers were analyzed, first with a self-assessment survey, then with researcher observations. Self-assessment and observations both showed similar results. Constructivist teachers were those that reported higher scores (125-117) on the CLES

instrument and also exhibited at least seven of the Constructivist behaviors in the classroom. Mixed teachers were those that reported middle scores (114-103) on the CLES instrument and upon observation, displayed a mixture of constructivist and traditional behaviors in the classroom. These teachers possessed at least five of the Contructivist traits. Traditional teachers were those that reported lower scores (93-85) on the CLES instrument. Upon observation, these teachers displayed mainly traditional behaviors in the classroom, and displayed four or fewer of the Constructivist traits. Of the 13 teachers participating in the survey, 5 were designated as constructivist, 5 as mixed, and 3 as traditional.

Quantitative results employing a Multivariate Analysis of Variance reported significant main effects between teacher type and Higher-Order Skills scores and significant interaction effects between ethnicity, teacher type and Higher-Order Skills scores (see Table 16). The significant main effect of Teacher Type on Higher-Order Skills scores (Hypothesis 2), indicated that teachers designated as traditional had higher means on this measure. This finding does not support the researcher's hypotheses that constructivist teachers would have the higher Higher-Order Skills test outcomes. The significant interaction effect of teacher type and ethnicity for Higher-Order Skills scores (Hypothesis 6) indicated that Caucasian students had the highest mean scores for mixed teachers, and that Minority students had the lowest mean scores for constructivist teachers, as measured by Higher-Order Skills scores.

Chapter V

Discussion and Implications

The purpose of this research was threefold. The first purpose was to determine whether or not constructivist (student-centered) versus traditional (teacher-centered) teacher type effected Standards of Learning test scores and Higher-Order Skills comprehension scores for 8th grade physical science students. The second purpose was to determine if teacher type effected test outcomes as a function of gender. The third purpose was to determine if teacher type effected test outcomes as a function of ethnicity.

I. Summary of Previous Chapters.

Chapter one provided an introduction and an overview of the current issues regarding American science education and achievement as they pertain to teaching types, namely constructivist, mixed and traditional. Included in the introduction was research on classroom environment, educational significance of the study, statement of purpose, theoretical framework, hypotheses, methodology, limitations, and definitions.

Chapter two presented a review of the research and theory related to the topic of teaching pedagogy and achievement. The topics in chapter one were expanded with a more thorough review of the literature. Included in the relevant literature were the following studies supporting the various components of constructivism:

Palinscar (1983, 84, 96) stated that students increased their comprehension ability after receiving "reciprocal teaching" instruction which features dialogue between teachers and students and ensuring that teachers are coaches, while students assume most of the responsibility of the lesson. Musheno & Lawson (1999) found that in learning cycle reading groups, students earned higher concepts comprehension scores at all

reading levels than more traditional groups. Heide (1989) found that too much teacher-directed instruction has either negative effects at worst or neutral effects at best on children's development. Johnson & Johnson (1991) said that achievement is greater when learning situations are structured cooperatively rather than competitively or individualistically. According to Slavin et al (1985), achievement in classes with cooperative groups was significantly higher than in more traditional classes. Chang (1994) stated that constructivist, student-centered classrooms produced students who scored much higher when asked to explain scientific phenomena, than students in traditional classrooms.

In support of direct instruction, Engelmann (1969-72) found that direct instruction models of instruction were superior in terms of placing students first in reading, math, spelling and language. Finn & Ravitch (1996) call constructivism faddish and claim that it excludes content. Bey et al (1992) discovered that constructivist and traditional groups score the same on initial post tests.

Chapter three explained the design of the research study. It included the research questions and hypotheses, description of setting and participants, sampling design, and description of instruments. Data were collected by various means. The CLES was used to gather data from 8th grade science teachers in the Norfolk Public School System. Researcher observation augmented for validation purposes the data gathered from the survey.

A summary of the findings was presented in chapter four. This chapter was divided into two sections. Section one provided the results for the analysis of data gathered through the CLES survey regarding teacher self-assessment. Section two

provided the results for the analysis of data from the Standards of Learning test for 8^{th} grade science, and the Higher-Order Skills test.

This chapter examines findings of the current study, discusses implications and makes recommendations for future research. It addresses the effects of classroom type on achievement, effects of gender and teacher type on achievement, effects of ethnicity and teacher type on achievement, recommendations, and summary.

II. The effects of Teacher Type on achievement.

The first two research questions are addressed in this section: What teacher types characterize this sample of 8^{th} grade science classes, and do children who receive instruction in constructivist classrooms perform better on achievement and comprehension tests than children who receive instruction in traditional classrooms? This study investigated the influence of teacher pedagogy on outcomes as measured by the Virginia Standards of Learning Test (SOL) and the Higher-Order Skills Test (HOS). Specifically, the study sought to determine whether constructivist versus traditional teacher types/orientation effected scores on these two measures. In order to examine whether constructivist teacher types contributed to higher comprehension on 8^{th} grade science tests, teacher types were determined for 13 teachers participating in this study, then analyzed with both quantitative and qualitative methods.

The findings of this study were varied, some contradicting previous research, some supporting it. The results indicated that teacher type makes no difference when measuring standardized test outcomes, and that traditional to mixed classroom settings result in higher comprehension test outcomes. However, there is much literature reporting that constructivist teaching practices contribute to higher test scores (Musheno & Lawson,

1999, Heide, 1998). There also seems to be evidence to support constructivist teaching strategies that employ conceptual learning that does not isolate basic skills, but that incorporates them into skills required for completion of real problem-solving tasks (Applefield et al, 2001). Walker (1999) reported that students taught with constructivist teachers had a higher probability of answering mathematical items that measured conceptual understanding correctly, than students taught in traditional classrooms (Walker, 1999). Constructivism has been very successful in mathematics instruction where students have historically done poorly in terms of understanding certain mathematical concepts, such as giving students relevant examples to solving analogous problems that have some connection to similar problems and prior knowledge (Chen, 1999).

In contrast to constructivism, traditional teaching practices have been shown to be inferior to constructivist teaching practices as measured by delayed posttest studies (Bey, et al, 1992, Gatlin, 1998). However, both groups learned equally well as measured by an initial posttest (Bey, et al, 1992). Constructivism has also been called faddish, excluding content (Finn & Ravitch, 1996). The goals of Constructivism are to teach for real understanding and to develop problem-solving skills in students, and to take students to higher levels of learning in the classroom than simply memorization of facts. It would appear from the research that constructivist teaching practices would result in higher test scores in this study, however this was not the case.

The first hypothesis of this study was not supported, implying that in this case, teacher type did not contribute to higher test scores as measured by the Standards of Learning standardized test. The use of the mean of the SOL scores as a measure of central

tendency revealed that the teachers classified as constructivist teacher type possessed a slightly higher, though not statistically significant mean, than either mixed or traditional teachers, indicating only an 8 point difference from lowest to highest means (see Table 12). These scores are too similar to be attributed to differences in pedagogy.

These findings do not support the anecdotal evidence presented by many researchers who overwhelmingly claim that constructivist teaching practices contribute to higher test scores. The mean differences for constructivist, mixed and traditional teachers as pertaining to Standards of Learning scores were not statistically significant. This suggests that Standards of Learning scores for 8th grade science students were not influenced by teacher type.

Although the study did not support the hypothesis that constructivist teaching pedagogy raises standardized test scores, the reason for the findings obtained in this study may lie with the nature of the Standards of Learning test itself. The Standards of Learning test is a high-stakes test. Studies have shown that high stakes tests do not have a positive effect on teaching and learning; they do not motivate the unmotivated, and have been shown to increase dropout rates, particularly among minority populations (Madaus & Clarke, 2001). Also, in a North Carolina study, 236 elementary teachers reported high levels of stress and lower morale, a narrowed curriculum, and decreased student enthusiasm (Hargrove et al, 2000). Teachers across the district were under enormous pressure to have their students pass the test, failure to do so could result in loss of jobs and school accreditation. As a result, many teachers who scored high on the CLES survey indicating that they were constructivist, and had displayed constructivist traits during observation, could have resorted to "teaching to the test" by stressing

memorization and rote learning to ensure higher pass rates at the cost of comprehension. The Standards of Learning test also measured students on content and knowledge gained over a span of three years. On the 8th grade science SOL exam, students are exposed to questions from 6th, 7th and 8th grade science classes. During those three years, the students were exposed to three teachers with three different teaching styles, which could have confounded the results.

In a study conducted by Hardwick (1993), it was found that performance based assessment measures (such as the SOL test) will regress significantly with the constructivist learning environment. The constructivist epistemology inherently employs teaching techniques that allow students to express their personal understanding of scientific concepts in ways that are unique to them. Constructivist assessment is diametrically opposed to traditional standardized achievement tests that by definition are based on a norm group(Hardwick,1993). Osborne and Whittrock (1985) expressed similar concern regarding assessment that is fair to constructivism. There may be overlap in personal understanding in a standardized test, but the possibility of a standardized test to miss personally constructed meaning appears even more likely (Osborne & Whittrock, 1985).

High-stakes testing also incorporates performance instead of task or process goals. Theorists have described two achievement goals in particular, which have traditionally been defined in terms of their approach: the goal to develop ability (mastery, learning or task goal), and the goal to demonstrate ability (performance goals). However, research has shown that task goals are related positively to perceived ability, use of deep processing strategies, task engagement, attributions of success to effort, and persistence

in the face of difficulty (Anderman & Young, 1994; Dweck, 1986; Dweck & Leggett, 1988, Graham & Golan, 1991; Meece, Blumenfeld, & Hoyle, 1988; Midgley, & Urdan, 1995; Nicholls, Patashnick, & Nolen, 1985; Roeser, Midgley & Rudan, 1996; Schunk, 1996).

One of the components of constructivism is the concept of higher-level processing of information. Most studies have found that performance goals are unrelated to deep processing. This relationship between performance goals and the use of superficial strategies has been found consistently (Elliot et al, 1999). Research also has found a positive relationship between performance goals and the use of superficial strategies, such as would be employed in preparation of high-stakes testing. Performance goals have been shown to be related to maladaptive behaviors such as use of shallow cognitive strategies, lack of persistence, avoiding help seeking, and attribution of failure to lack of ability (Anderman & Young, 1994; Meece et al., 1988; Nolen, 1988; Ryan & Pintrich, 1997). The Standards of Learning test does not assess task goals, but performance ones, while constructivist teaching strategies stress task goals.

This leads to the question as to how performance based (authentic) assessment would better reflect a constructivist learning environment. Enabling students to examine their conceptions (to think about their answers and how they arrived at them) during instruction (Hand & Treagust, 1991) is essential in order for students to construct their own meaning. Traditional methods do not insure that students will ever be able to do this. As long as teachers are teaching to the test, then students will not be able to acquire science process skills (task goals) (Tobin & Gallagher, 1987), which cannot be measured by standardized tests.

Standardized tests also do not appropriately reflect and measure constructivist teaching strategies. In a correlational study conducted by Hardwick (1993), collaboration, prior knowledge and reflection all displayed significantly positive correlation with cognitive achievement measures, while standardized achievement test scores did not. It is suggested that constructivist teaching practices be measured by forms of assessment other than multiple-choice standardized tests, since there is a question as to the merit of measuring open-ended teaching styles with closed-ended tests. Assessment instruments need to accurately measure constructivist teaching practices. The Higher-Order Skills test was designed to measure more open-ended higher-level knowledge (namely comprehension) than the Standards of Learning test. It included essay items that required the students to explain their multiple-choice answers.

The second hypothesis of this study was supported, indicating that teacher type did influence comprehension test outcomes as measured by the Higher-Order Skills test, however, contrary to expectations, the results revealed that traditional teachers scored the highest mean, while constructivist teachers scored the lowest mean.

The results revealed that teacher characteristics that employ mainly traditional methods seemed to be more successful with students as pertains to Higher-Order Skills scores. Constructivist teaching practices were not as successful in producing higher comprehension scores. Students in classes with traditional teachers had the highest outcomes on the Higher-Order Skills test, indicating that in this study, traditional methods that employed memorization and multiple-choice test taking strategies worked best in raising test scores.

Although findings imply that traditional teaching practices promote higher comprehension in the classroom, however, one must consider again the nature of the test. The Higher-Order Skills test was a combination of multiple-choice and open-ended short essay answers. In this situation, all of the questions on the test were based on the Standards of Learning standardized test, but also further required the students to explain their answer.

Although research shows that open-ended essay tests are more accurate measures of constructivist classroom achievement (Hardwick, 1993) in this case, traditional teaching practices seemed to raise comprehension. As mentioned earlier, the Standards of Learning test covers material that spans three school years and three different teachers, all, perhaps with different teacher styles. The Higher-Order Skills test was written from the Standards of Learning test, and explanations for answers to questions from material that the student learned one to three years prior, could have attributed to the low comprehension scores with constructivist teachers. Those teachers that taught to the test (the more traditional teachers) seemed to elicit higher scores than the more constructivist teachers. There was also the pressure to pass the Standards of Learning test that the Higher-Order Skills test was taken from, and a good deal of "cramming" and repetitive learning may have taken place in all of the classrooms. These findings suggest that traditional teaching practices are effective in raising comprehension scores and that teachers may prepare their students more effectively for high-stakes standardized testing through the use of traditional teaching techniques, although again, the nature of the tests themselves must be considered.

Other possible reasons for the findings obtained in this study lies in the violation of rules and directions given to teachers in School C to differentiate their Higher-Order Skills tests by student and teacher. School C had to be discarded for failure to separate Higher-Order Sills tests and they were all turned in together with no delineation as to teacher. School C possessed one of the most constructivist teachers. A third possible reason for the findings lies in another violation of rules and directions on behalf of the traditional teachers. No Standards of Learning tests or Higher-Order Skills tests for students of the traditional teachers were differentiated by sex and gender. The failure to do so on the part of the traditional teachers resulted in data concerning teacher type but not gender and ethnicity for traditional teachers.

III. Effects of gender and teacher type on achievement.

As noted in the introduction, one of the reasons gender differences were explored was because there was some evidence suggesting that constructivism was more beneficial to girls than other teacher pedagogies (AAUW Report, 1992). The third research question addressed whether or not there is a difference in achievement and comprehension outcomes as a function of gender and teaching styles? One of the components of constructivism is cooperative learning groups. A number of positive outcomes have been attributed to cooperative groups, especially among girls. When done correctly, cooperative learning is designed to reduce competitiveness while increasing cooperative spirit, benefiting girls especially (AAUW Report, 1992). In a study conducted by Hardwick (1993), female middle school science students had higher end of year grades and higher perceptions of collaboration than the males (Hardwick,1993). Science is a social subject by its nature, and girls assume human connection naturally, therefore

benefiting from cooperative groups (Gilligan, 1993). Also, girls bring their own meaning to situations that may be different from their male counterparts and originating from different life experiences; a constructivist notion (Gilligan, 1993).

In light of this research, it would appear that females would score higher in constructivist classrooms on outcome measures than males, however the third hypothesis of this study that suggested that gender and teacher type would effect SOL scores, was not supported. Findings suggest that overall, males fared slightly better, though not statistically significant, as measured by Standards of Learning scores when taught by constructivist teachers, while students of both sexes scored similarly when taught by mixed teachers (see Table 17). Students of both sexes taught by traditional teachers manifested the lowest mean, however these students were analyzed in sum and not designated by gender (see Table 17).

Research suggests that the constructivist classroom environment in general and especially cooperative learning groups enhance learning in all students, especially females. Small-group work tends to stimulate higher levels of cognitive achievement than does listening to lectures. Students also benefit from working in groups, both in conducting labs and in developing explanations, interpretations and conclusions (Saunders, 1992). Current research also shows that females benefit from constructivist practices that include cooperative groups, as girls are more social in nature (Gilligan, 1993), however, this study did not bear this out, indicating that boys fared better in classrooms with constructivist teachers when measured with the Standards of Learning test. The findings of this study suggest that constructivist practices did not affect outcomes in regard to the interaction of teacher type and gender (see Table 15).

One might ask however, if the pre-conceived notion of the student by the teacher affects how well the student does in that subject? Future research should focus on pre-conceived notions of gender-based ability and test outcomes. Kahle et al. (1993) suggests that there is a gender effect that is associated with the expectations of teachers towards boys and girls in science. This gender effect is manifested when expectations, interactions, or measured achievements are related to sex rather than to potential. Because of this, the gender effect influences a girl's attitudes towards science, their self-confidence towards the subject, and their motivation to continue studying science (Kahle et al., 1993). Ernest (1976) surveyed teachers and found that 63% believed boys were naturally better at math than were girls. More recently, Yee and Eccles (1988) reported that parents believed that math was more difficult for their daughters than for their sons. Two decades of intervention programs in math and science education have found similar gender-based differences in attitudes, achievement, motivation and self-confidence to study math and science (Catsambis, 1994; Elmore & Vasu, 1986; Yee & Eccles, 1988; Hyde, Fennema, Ryan, Frost & Hopp, 1990). Many successful models have been implemented in order to rectify this (Eccles et al., 1983, Fennema & Peterson, 1985).

Although research suggests that classroom and course grades are higher for girls in constructivist classrooms due in part to cooperative learning groups and open discussions, research also suggests that standardized tests may be biased against girls. Studies show that course grades show higher achievement for girls than for boys, however, gender differences continue to be found in the results of standardized achievement scores that do not reflect classroom grade point averages (Parker & Offer, 1987, Rennie & Parker, 1991). The Standards of Learning test outcomes did not effect the course grades for 8^{th}

grade science for the students participating in this study. Sex differences favor boys by about 50 points on the Scholastic Achievement Test (SAT). This difference has remained constant over the last several decades (Halpern, 1992). Brown and Josephs (1999) found that while girls do not have performance concerns during daily classroom tests, the typical standardized-testing environment tends to heighten the performance concerns of females, where a gender gap in performance was revealed.

Again, the nature of the Standards of Learning test as a high-stakes standardized test, could have affected the outcome in favor of males. This study also analyzed the effects of the interaction between gender, teacher types and comprehension scores as measured by the Higher-Order Skills test. The fourth hypothesis of this study that suggested that gender and teacher type would effect Higher-Order Skills test outcomes, was not supported. Although not significant, results reveal that females scored a higher overall mean than males when taught by mixed teachers. The lowest mean belonged to males who were taught by constructivist teachers (see Table 17). These findings do not support the hypothesis that teacher type interacting with gender would effect comprehension outcomes as measured by the Higher-Order Skills test.

It should be noted that the second highest mean also belonged to females who were taught by constructivist teachers. Although these findings are not significant, females did better overall when measured by the Higher-Order Skills test. It appears that teacher type did not have as much influence on gender as was hypothesized. As mentioned earlier, girls may have a bias against them manifested through teacher and parental attitudes. Yee and Eccles (1988) reported that parents believed that math was more difficult for their daughters than for their sons. Two decades of intervention programs in math and science

education have found similar gender-based differences in attitudes, achievement, motivation and self-confidence to study math and science (Catsambis, 1994; Elmore & Vasu, 1986; Yee & Eccles, 1988; Hyde, Fennema, Ryan, Frost & Hopp, 1990). Many successful models have been implemented in order to rectify this (Eccles et al., 1983, Fennema & Peterson, 1985). These findings refute evidence found in current research that shows female students benefit from constructivist teaching practices (Gilligan, 1996), however, again, the nature of the high-stakes testing situation should be taken into consideration. High stakes accountability testing programs influence what teachers teach and what students learn (Darling-Hammond, 1990; Linn, 1993; Torrance, 1993).

IV. The effects of ethnicity and teacher type on achievement.

The fifth hypothesis of this study suggesting that ethnicity and teacher type would effect Standards of Learning test outcomes, was not supported. Results from this study indicate that teaching styles did not raise Standards of Learning test outcomes when interacting with Ethnicity. Results indicate that Caucasians had the highest mean scores with both constructivist and mixed teachers having the same mean. Students with traditional teachers scored the lowest mean (see Table 18). In this case, Caucasian students in mixed and traditional classes fared better than those in traditional classes, however, these findings imply that the interaction of ethnicity and teacher type does not appear to be a factor that significantly influences outcomes in this particular standardized test.

Although the interaction of ethnicity and teacher type did not effect Standards of Learning test results, it did effect Higher-Order Skills test results. The sixth hypothesis of this study that suggested that ethnicity and teacher type would effect Higher-Order Skills

scores was supported. Caucasians scored the highest mean when taught by mixed teachers, and the lowest mean was scored by Caucasians taught by constructivist teachers.

These findings are significant in that they support the hypothesis that interactions of ethnicity and teacher type would effect Higher-Order Skills comprehension scores, however they do not support the notion that constructivist teaching practices would result in higher comprehension scores. Constructivist teaching practices employ strategies that require group cooperation and active participation. The results of this hypothesis suggest the need for school administrators and teachers to better address the needs of Minorities, especially Minority males, who may not be taking advantage of or be exposed to cooperative groups, open discussion and student-centered atmospheres, which are components of constructivist education practices. Urban minority males may not have been taught to work cooperatively or collaboratively, due to urban teachers feeling the need to enforce strict discipline in urban classrooms, which fosters a more traditional teaching approach. As a result, Minority males may have fewer experiences with cooperative learning groups than their Caucasian classmates. Deeper societal dysfunctions may also lie at the root of many Minorities failing to perform up to their abilities (Fordham & Ogbu, 1986). Minorities have been shown to be more autonomous than Caucasian students, therefore not taking ownership of the cooperative nature of group work with constructivist teaching practices (Hardwick, 1993).

There is research however, that supports cooperative learning as beneficial for African-American students, suggesting that Minority students respond better to cooperative and collaborative learning versus competitive learning (Madaus & Clarke,

2001). Excessive use of competition can hinder minority students' achievement, damaging academic motivation and educational engagement (Ford & Thomas, 1997). Minority students need more opportunities to be in a constructivist learning environment in their science classrooms. The perception by minority students could be due to expectations that restrict minority students to "basic skills" which disenfranchise them from the learning opportunities found in collaboration, and reflection. Hardwick (1993) found that Minority students perceived less collaboration, prior knowledge and reflection in a middle school classroom when measured by a self-scoring survey instrument. Their Caucasian peers however, perceived more positively the notion of collaboration, prior knowledge and reflection and had higher achievement score.

Black students and other minorities face substantial self-evaluative anxiety (Wine, 1971) that may impede performance on already stressful standardized tests, creating a self-fulfilling prophecy. Negative stereotyping about one's group leads to self-doubt that may confirm the group stereotype, which then leads to poorer performance. Such cycles may cause stigmatized students to devalue and disidentify with the performance assessment (Crocker & Major, 1989; Steele, 1997). Future research should identify the specifics of the stereotype-threat experience for particular groups (i.e. the nature and content of their performance concerns) to best design strategies for overcoming these effects.

Also, minorities may feel intense pressure not to succeed in school. Fordham and Ogbu (1986) found that able minority students faced strong peer pressure not to succeed. If they did well in their studies, they might be perceived as "acting white". Peer group pressure took on many forms, including name-calling, exclusion from peer activities, and

physical assault (Fordham & Ogbu, 1986). This is an understudied area of goal theory research that should be pursued, especially in terms of performance goals and assessment. All of these research findings may have manifested themselves in the results of this study. Contrary to the hypotheses, Minority students did not benefit from constructivist practices.

V. Recommendations.

It is recommended that future research with teacher pedagogy not rely on the outcomes of high-stakes testing, but rather teacher-designed multiple-choice tests. The temptations to teach to the test may have been too great for true teacher styles to be addressed in this study. Because of the nature of the Standards of Learning test, students taking the test were exposed to three different teachers over the course of the three years that the material was taught (the Standards of Learning test consisted of questions from 6^{th}, 7^{th} and 8^{th} grade science classes). Teaching styles were only measured for teachers the students had currently and who administered the test. Future studies could limit the range of the test to include only material covered by one teacher in a shorter time frame, thus limiting any confounding variables inherent in this study.

Standardized tests also may not appropriately reflect and measure constructivist teaching strategies. In a correlational study conducted by Hardwick (1993), collaboration, prior knowledge and reflection all displayed significantly positive correlation with cognitive achievement measures, while standardized achievement test scores did not. It is suggested that constructivist teaching practices be measured by forms of assessment other than multiple-choice standardized tests, since there is a question as to the merit of measuring open-ended teaching styles with closed-ended tests, and also to better measure

constructivist teacher success with comprehension scores by controlling for passage of time between material and test (excluding the SOL test), also ensuring that only one teacher deliver and then test the material, and the employment of multiple-choice tests that are not high-stakes in nature.

One of the goals of constructivist teaching strategy is to foster retention and not memorization. Mastery or task goals, not performance-approach goals, facilitate retention (Elliot & McGregor, 1999). Another recommendation would be to administer the Higher-Order Skills test as a delayed post-test to better gauge the retention of the students taught by constructivist teachers versus those taught by more traditional teachers. According to research, constructivist teachers report higher delayed post-test scores than do traditional teachers (Bey et al, 1992, Gatlin, 1998), even though both groups do similarly well on initial post-tests.

Future studies also should address the relationship between constructivist teaching practices and open-ended essay exams. There are few studies investigating whether or not constructivist pedagogy raises scores on essay exams, as opposed to more traditional teaching methods. According to research, constructivist strategies foster comprehension and higher-order skills, which are those measured on most essay tests (Palinscar et al, 1984, 1986, Gatlin, 1998). Also, alternative forms of assessment other than traditional tests may be the best way to measure achievement in constructivist classrooms (Hardwick, 1993). Perhaps future studies could address the nature of essay exams and constructivist teaching practices by measuring only exams with open-ended questions, and not comparing them to standardized, multiple-choice tests.

It also would be beneficial to study whether or not constructivist practices such as

cooperative groups and discussion formats benefit males, and how males interact in cooperative groups. Should males and females be taught differently? Gallagher and DeLisi (1994) found that although girls and boys answered equal numbers of SAT mathematics questions correctly, girls tended to employ more conventional pre-taught strategies, while boys employed more untaught strategies (Gallagher & DeLisi, 1994). Future research should focus on alternative assessments as the instruments for measuring achievement in females, and also examine the effects of performance concerns in situations that involve practical consequences for performance (such as with the Standards of Learning test) for females.

In contrast to the current reform movement's focus on authentic integrated knowledge application, traditional standardized achievement tests include isolated items of factual and basic recall information with multiple-choice response formats (Linn, 1993; Smith, 1991; Wilson, 1992). The result is that these tests prompt teachers to emphasize basic facts and to provide students with few opportunities to apply information learned (Darling-Hammond, 1990; Wilson, 1992). Learning environments that include high-stakes testing could confound results that could otherwise be significant. A case study of assessment practices from Victoria, Australia, indicated how changes in a state-wide end-of-schooling credential, the Victorian Certificate of Education (VCE), dramatically changed the achievement of girls relative to boys in physics. A twenty-year bias in assessment that favored boys, was turned around when a wider variety of activities, skills and tasks became part of the common assessment task format for the VCE (Hildebrand, 1996). Urdan (1997)reported that for boys but not for girls, there was a positive relationship between performance-approach goals (which are measured by tests

such as the Standards of Learning) and the use of metacognitive strategies. Also, does the pre-conceived notion of the student by the teacher affect how well the student does in that subject? Future research should focus on pre-conceived notions of gender-based ability and test outcomes.

The results of the research on ethnicity and teacher type, suggest that teaching practices that include more traditional methods may benefit Minority students. Therefore, a closer analysis and investigation of these teaching practices as they pertain to outcome measures is warranted. Also, investigations as to why constructivist practices have not been historically successful with Minority populations should be explored.

Again, when considering these findings, the nature of the Standards of Learning test must be acknowledged. Recommendations for future study should include the effects of high-stakes testing (similar to the Standards of Learning test) on Minorities. Research shows that high-stakes testing programs do not motivate the unmotivated and that they have been shown to increase high school dropout rates, especially among Minority populations (Madaus & Clarke, 2001). Performance based assessments, such as the Standards of Learning test, have been shown to be poor measurement tools in determining the learning levels of African-American students.

Bouffard et al, found that an orientation to performance goals predicted grades in math and English for whites only (Bouffard et al, 1995). Steele and Aronson (1995) conducted a study where black and white students took a test of verbal intelligence but told half the students that the test was a practice test and wouldn't count. Black students performed much better when they thought the test didn't count than when they believed it would truly measure their abilities; no such difference was observed among white students. In a

follow-up study, Steele told the students that the test they were taking was nondiagnostic of intelligence and ability and primed the racial identities of half of these students prior to testing simply by having them indicate their race on a biographical section of the test form. Congruent with prior results, the black, race-primed students underperformed as compared with their black, non-race-primed peers. Steele and Aronson observed no such effects among the white students. Thus, it appeared that simply reminding the black students of their racial affiliation was enough to initiate the racial stereotype threat of inferiority, creating defects in performance among the stigmatized students (Steele & Aronson, 1995).

VI. Summary

The first two research questions addressed the topic of the effects of classroom orientation on achievement in Section one. The first hypothesis of this study: *There will be a difference in achievement by teacher type as measured by the Standards of Learning scores*, was not supported. It is possible that the nature of high-stakes testing which stress performance may have contributed to the outcomes. Recommendations include that future research with teacher pedagogy not rely on the outcomes of high-stakes standardized tests. Also, assessment instruments that better measure constructivist teaching strategies, incorporating authentic assessment, should be implemented.

The second hypothesis of this study was supported, indicating that classroom orientation did influence comprehension test outcomes as measured by the comprehension measurement: *There will be a difference in comprehension by teacher type as measured by Higher-Order Skills scores.* These findings indicate that teacher characteristics employing mainly traditional methods were more successful than

constructivist practices. Since the Higher-Order Skills test was written from the Standards of Learning test, results imply that the nature of the high-stakes testing experience could have negated the effects of the constructivist teaching styles on test outcomes. Recommendations include better controls over the passage of time between instruction and testing, ensuring that only one teacher type is measured, that the measurement instrument is not high-stakes in nature, and the examination of the relationship between constructivist teaching practices and open-ended essay exams. Also, administering the comprehension measurement as a delayed-post-test would better measure retention instead of memorization.

The third research questions addressed the topic of the interaction of gender and teacher type and its effect on test outcomes. The third hypothesis of this study: *There will be a difference in achievement by gender and teacher type as measured by Standards of Learning scores*, was not supported. Differences in scores between males and females were not great enough to have been effected by teaching styles as measured by the Standards of Learning test.

Future research should focus on components of constructivist learning practices, such as cooperative groups, and how they benefit males, preconceived notions of student efficacy by teachers based on the gender effect could be controlled for, high-stakes testing and the standardized test bias against girls, and performance concerns brought about by these stereotypes should be addressed.

The fourth hypothesis of this study was not supported: *There will be a difference in comprehension by gender and teacher type as measured by Higher-Order Skills scores.* Teacher type did not have as much influence on gender outcomes as the hypothesis

suggested. Again, future research should examine more closely the relationship between gender, teacher practices and assessment strategies that are not biased against girls.

The third research question addressed the effects of Ethnicity on achievement. The fifth hypothesis was not supported: *There will be a difference in achievement by ethnicity and teacher type as measured by Standards of Learning scores.* These findings imply that the interaction of ethnicity and teacher type does not appear to be a factor that effects outcomes on this particular standardized test. The effects of high-stakes testing on minorities should be examined more closely, including stereotyping by teachers and students, and pressures not to succeed in school.

The sixth hypothesis of this study was supported: *There will be a difference in comprehension by ethnicity and teacher type as measured by the Higher-Order Skills scores.* Caucasians scored the highest mean when taught by mixed teachers, indicating that constructivist practices were not as successful as the hypothesis suggested. Minority experience with cooperative groups and components of constructivist teaching and learning strategies may be limited, therefore future studies focusing on Minorities and constructivism are warranted. High-stakes testing does not adequately measure Minority achievement, although traditional teaching methods may benefit Minorities. A closer analysis of these teaching practices as they pertain to outcome measures is needed, along with investigation as to why constructivist practices have not been historically successful with Minority populations.

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Appendix A

The Revised Constructivist Learning Environment Survey

CLES:The Revised Constructivist Learning Environment Survey

What happens in my science classroom?
Teacher form

Directions

1. **Purpose of the Questionnaire**
   This questionnaire asks you to describe important aspects of the science classroom which you are in right now. There are no right or wrong answers. Your opinion is what is wanted. Your answers will enable us to improve future science teaching.

2. **How to Answer Each Question**
   On the next few pages you will find 30 sentences. For each sentence, circle only one number corresponding to your answer. For example:

		Almost Always	Often	Sometimes	Seldom	Almost never
In this class...						
8	I ask the students questions.	5	4	3	2	1

- If you think that you *almost always* ask the students questions, circle the 5.
- If you think that you *almost never* ask the students questions, circle the 1.
- Or you can choose the number 2,3 or 4 if one of these seems like a more accurate answer.

3. **How to Change Your Answer**
   If you want to change your answer, cross it out and circle a new number. For example:

8	I ask the students questions.	~~5~~	4	3	2	1

4. **Course Information**
   Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

a. Name:	b. School:
c. Grade/Year-level:	d. Sex male/female (please circle one)

5. **Completing the Questionnaire**
   Now turn the page and please give an answer for every question.

Learning about the world	Almost Always	Often	Some-times	Seldom	Almost Never
In this class…					
1 Students learn about the world outside of school.	5	4	3	2	1
2 Students' new learning starts with problems about the world outside of school.	5	4	3	2	1
3 Students learn how science can be part of their out-of-school life.	5	4	3	2	1
In this class…					
4 Students get a better understanding of the world outside of school.	5	4	3	2	1
5 Students learn interesting things about the world outside of school.	5	4	3	2	1
6 What students learn has nothing to do with their out-of-school life.	5	4	3	2	1
Learning about science					
In this class…					
7 Students learn that science cannot provide perfect answers to problems	5	4	3	2	1
8 Students learn that science has changed over time	5	4	3	2	1
9 Students learn that science is influenced by people's values and opinions.	5	4	3	2	1
In this class…					
10 Students learn about the different sciences used by people in other cultures.	5	4	3	2	1
11 Students learn that modern science is different from the science of long ago.	5	4	3	2	1
12 Students learn that science is about inventing theories	5	4	3	2	1

	Almost Always	Often	Sometimes	Seldom	Almost Never
Learning to speak out					
In this class...					
13 It's ok for students to ask me "why do I have to learn this?"	5	4	3	2	1
14 It's ok for students to question the way I'm teaching.	5	4	3	2	1
15 It's ok for students to complain about activities that are confusing.	5	4	3	2	1
In this class...					
16 It's ok for students to complain about Anything that prevents them from learning.	5	4	3	2	1
17 It's ok for students to express their opinions.	5	4	3	2	1
18 It's ok for students to speak up for their rights.	5	4	3	2	1
Learning to learn					
In this class...					
19 Students help me to plan what they're going to learn.	5	4	3	2	1
20 Students help me to decide how well they are learning.	5	4	3	2	1
21 Students help me to decide which activities are best for them.	5	4	3	2	1
In this class...					
22 Students help me to decide how much time they spend on activities.	5	4	3	2	1
23 Students help me to decide which activities they do.	5	4	3	2	1
24 Students help me to assess their learning.	5	4	3	2	1
In this class...					
25 Students get the chance to talk to other students.	5	4	3	2	1

		Almost Always	Often	Some-times	Seldom	Almost Never
26	Students talk with other students about how to solve problems.	5	4	3	2	1
27	Students explain their ideas to other students	5	4	3	2	1

In this class...

28	Students ask other students to explain their ideas.	5	4	3	2	1
29	Students ask each other to explain their ideas.	5	4	3	2	1
30	Students explain their ideas to one another.	5	4	3	2	1

Appendix B

Higher-Order Skills Test (Comprehension Measurement)

COMPREHENSION MEASUREMENT
8th grade Physical Science
Supplement to VA Standards of Learning Test

Numbers of questions are followed by the corresponding SOL and SOL test question number.

1. (6.1) (3) **Hypothesis: If the amount of nitrogen fertilizer is increased, then the height of the corn increases.**

   What would the independent variable be for an experiment testing this hypothesis, and WHY would that be the independent variable?

2. (6.3) (12)**Which of the four energy sources is most important for cars and WHY?**

   A. Solar cells
   B. Fossil fuels
   C. Denatured alcohol
   D. Wood

   Explain why here:

3. (6.3) (13)**Which of these best shows a change from solar energy to chemical energy?**

   A. Evaporation of water
   B. Heating of pavement
   C. Photosynthesis in leaves
   D. Formation of rainbows

   Explain why here:

4. (6.4)(14) **Which of these forms of energy can be produced by passing the magnet through the coil of wire?**

A. Nuclear energy
B. Light energy
C. Chemical energy
D. Electrical energy

Explain why here:

5. (6.4)(15) **Describe WHY this is a series circuit.**

6. (6.7) (18) **Why is a candy bar melting an example of a physical change as opposed to a chemical change?**

7. (6.7) (19) **Explain why the process of iron combining with oxygen to form rust is considered a chemical change.**

8. (PS.2) (20) **Describe how the particles in a solid would be arranged as opposed to a gas or liquid.**

9. (PS.2) (21) **Explain why Carbon Dioxide gas is a compound, instead of a mixture.**

10. (P.S.2) (22) **Explain why some thermometers contain alcohol.**

11. (P.S. 3) (23) **Describe the part electrons play in chemical reactions.**

12. (P.S. 5) (24) **In the chemical equation:**

    CH + 2O   CO + 2H O

    Which are the products and how did you arrive at your answer?

13. (P.S. 5) (25) **Hydrochloric acid reacts with sodium hydroxide to release water and sodium chloride. Why is this a balanced chemical equation for this reaction?**

    HC1 + NaOH   H O + NaCl

14. (P.S.7) (26) **Describe what would have to happen to merc~~ury for it to change in~~to a gas.**

15. (P.S.8) (27) **Explain how sonar uses sound waves to measure the distance between objects underwater.**

16. (P.S.10) (28) **According to the scientific definition of work, provide a brief scenario describing work being done.**

17. (P.S.11) (29) **Why is glass such a poor electrical conductor?**

18. (LS.2) (30) **Describe the contribution of the mitochondrion to cell function.**

19. (LS.2) (31) **Animals and plants get their food in different ways. Explain why animals can ingest their food while plants must produce their food.**

20. (LS 3) (33) **Given these four: organs, cells, tissues, systems: draw a flow chart from smallest to largest, along with an explanation of your drawing.**

21. (LS 5) (35) **Where does a lobster wear its skeleton and what is it called?**

22. (LS.13) (36) **Why would the color of a kernel of corn be a genetic factor rather than environmental?**

23. (LS. 9) (39) **What is a niche?**

24. (LS.12) (44) **Describe how overhunting and loss of habitat could contribute to the near-extinction of the bison.**

Appendix C

8th Grade Middle School Standards of Learning Test for Science

Science Test

GRADE

Reporting Category: Scientific Investigation

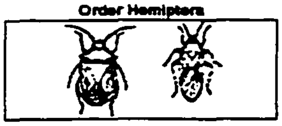
A. Standard of Learning: 6.1 The student will plan and conduct investigations in which

a) observations are made involving fine discrimination between similar objects and organisms.

Builds To: High school science courses require students to understand characteristics of organisms as they are used for classification.

A

1 **Order Hemiptera**



Based on the position of the wings, which of the insects below is most likely in the order Hemiptera?

A 

B 

C 

D 

Instruction: Provide students an opportunity to examine pictures of characteristics of an Order (Hemiptera) and then identify another member of the order.

B. Standard of Learning: 6.1 The student will plan and conduct investigations in which

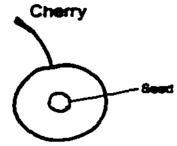
b) a classification system is developed based on multiple attributes.

Builds To: High school science courses require students to understand the development of classification systems.

B

2 **Key to Some Fruit Types**

1	Fruit with many seeds	Go to 2
	Fruit with only one or two seeds	Go to 6
2	Fruit with seeds on outside	Aggregate fruit
	Fruit with seeds on inside	Go to 3
3	Fruit with spine-like projections on skin	Multiple fruit
	Fruit with relatively smooth skin	Go to 4
4	Fruit soft with seeds inside a central papery core	Pome
	Seeds not in core	Go to 5
5	Seeds in a pod	Legume
	Seeds not in a pod	Berry
6	Fruit with wings for seeds	Samara
	Fruit with no wings	Go to 7
7	Soft fruit with single seed in center	Drupe
	Dry fruit	Go to 8
8	Thick hard shell around seed	Nut
	Very thin papery fruit so that fruit looks like seed	Achene



How should the fruit above be classified?

F Multiple fruit
G Pome
H Berry
J Drupe

Instruction: Provide students an opportunity to determine the classification of an organism based on characteristics.

Science Test

GRADE

A. Standard of Learning: 6.1 The student will plan and conduct investigations in which

f) hypotheses are stated in ways that identify the independent (manipulated) and dependent (responding) variables.

Builds To: High school science courses require students to form hypotheses and identify the independent and dependent variables.

A

3 Hypothesis: If the amount of nitrogen fertilizer is increased, then the height of the corn increases.

Which of these is the independent (manipulated) variable for an experiment testing this hypothesis?

- A The height of the corn in each experimental group
- B The number of corn plants in the experimental groups
- C The size of the experimental groups
- D The amount of fertilizer added to each experimental group

Instruction: Provide students an opportunity to read a hypothesis statement and identify the independent variable.

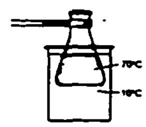
B. Standard of Learning: 6.1 The student will plan and conduct investigations in which

j) data are organized and communicated through graphical representation (graphs, charts, and diagrams).

Builds To: High school science courses require students to set up data tables and make charts and plot graphs.

B

4



Time (minutes)	Temperature (°C)		
	Glass	Clear Plastic	Plastic Foam
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

The picture above shows a flask of hot water in a container of cooler water. This test was carried out to find out which type of container would hold heat the longest. Which of these graphs best shows all of the data from this experiment?

F

G

H

J

Instruction: Provide students an opportunity to interpret a diagram of an experiment with the table of collected data in order to set up a graph.

Science Test

GRADE

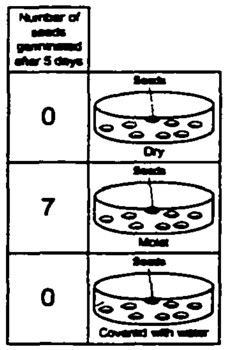
A. Standard of Learning: LS.1 The student will plan and conduct investigations in which

b) variables are defined.

Builds To: High school science courses require students to work with variables in experiments.

A

5



What is the variable being studied in this experiment?

A Seed number
B Amount of moisture
C Plant size
D Amount of light

Instruction: Provide students an opportunity to examine a diagram of an experiment and determine what variable is being studied.

B. Standard of Learning: LS.1 The student will plan and conduct investigations in which

c) SI (metric) units are used.

Builds To: High school science courses continue the use of metric units.

B

6 **Which metric measure would be best to use when measuring the amount of water given to a plant?**

F Meters
G Milliliters
H Centimeters
J Kilograms

Instruction: Provide students an opportunity to determine an appropriate metric measure for a given situation.

Science Test

GRADE

A. Standard of Learning: LS.1 The student will plan and conduct investigations in which

g) dependent variables, independent variables, and constants are identified.

Builds To: High school science courses require students to work with variables in experiments.

A

7 **Bean Plant Growth After 30 Days**

Brand of Fertilizer	Height of Plants (cm) Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean Height
A	52	53	51	50	52	51.6
B	58	58	55	56	57	56.8
C	51	52	50	53	52	51.6
No Fertilizer	46	48	46	49	47	47.2

The chart shows the results of a bean plant growth experiment. The plants received equal amounts of water and sunlight each day. Which of these is *not* an example of a constant in this experiment?

A Growing time
B Bean plant height
C Amount of sunlight
D Amount of water

Instruction: Provide students an opportunity to interpret a data table for an experiment with an explanation of the experiment and identify what CANNOT be a constant.

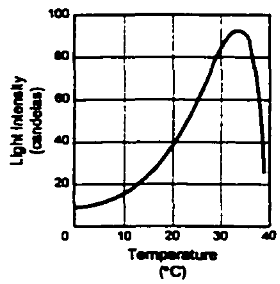
B. Standard of Learning: LS.1 The student will plan and conduct investigations in which

i) continuous line graphs are constructed, interpreted, and used to make predictions.

Builds To: High school science courses require students to set up graphs and interpret the information in a graph.

B

8



Artificial lights can create a great deal of heat. If a gardener wanted to grow seedlings indoors that grow best at 25°C, which light intensity should be used?

F 85 candelas
G 60 candelas
H 25 candelas
J 15 candelas

Instruction: Provide students an opportunity to interpret a line graph to answer a specific question.

Science Test

GRADE

A. Standard of Learning: LS.1 The student will plan and conduct investigations in which

j) interpretations from the same set of data are evaluated and defended.

Builds To: High school science courses require students to interpret data to determine relationships between variables.

A

9

Mouse Number	Food	Week 1 Mass Gain	Week 2 Mass Gain	Total Mass Gained
1	Rice	6 g	8 g	14 g
2	Grain	5 g	4 g	9 g
3	Corn	8 g	4 g	12 g
4	Mixture	12 g	8 g	20 g

Using the above table, what can you say about the relationship between each food and the mass of the mouse?

A The mixture-fed mouse gained the most mass.

B The rice-fed mouse gained the least mass

C The grain-fed mouse gained more mass in week 2.

D The corn-fed mouse gained less mass in week 1.

Instruction: Provide students an opportunity to interpret data in a table to establish a relationship between variables.

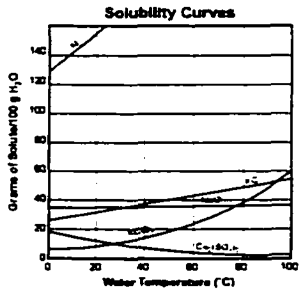
B. Standard of Learning: PS.1 The student will plan and conduct investigations in which

c) data from experiments are recorded and interpreted from bar, line, and circle graphs.

Builds To: High school science courses require students to set up graphs and interpret the information in a graph.

B

10



According to the graph, which of these is *least* soluble in water at 20°C?

F KI

G $KClO_3$

H NaCl

J $Ce_2(SO_4)_3$

Instruction: Provide students an opportunity to interpret a multi-line line graph.

Science Test

GRADE

A. Standard of Learning: PS.1 The student will plan and conduct investigations in which

f) valid conclusions are made after analyzing data.

Builds To: High school science courses require students to analyze data to make conclusions.

Reporting Category: Force, Motion, Energy, and Matter

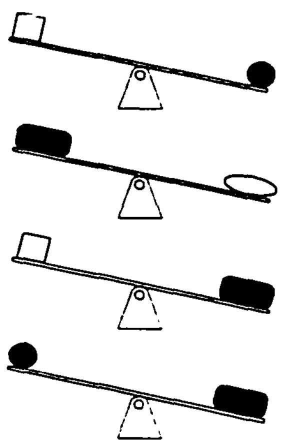
B. Standard of Learning: 6.3 The student will investigate and understand sources of energy and their transformations. Key concepts include

b) energy sources (fossil fuels, wood, wind, water, solar, and nuclear power).

Builds To: High school science courses require students to understand energy sources and their effect on the Earth.

A

11



Which one of the above objects is heaviest?

Instruction: Provide students an opportunity to make a conclusion after analyzing a diagram.

B

12 Which energy source is most important for cars?

F Solar cells
G Fossil fuels
H Denatured alcohol
J Wood

Instruction: Provide students an opportunity to investigate energy sources and uses.

Science Test

GRADE

A. Standard of Learning: 6.3 The student will investigate and understand sources of energy and their transformations. Key concepts include

c) energy transformations (mechanical to electrical, electrical to heat/light, chemical to light, and chemical to electrical/light).

Builds To: High school science courses require students to have an understanding of energy transformations.

A

13 **Which of these best shows a change from solar energy to chemical energy?**

A Evaporation of water
B Heating of pavement
C Photosynthesis in leaves
D Formation of rainbows

Instruction: Provide students an opportunity to investigate conversion from solar energy to chemical energy.

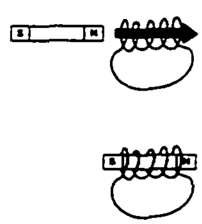
B. Standard of Learning: 6.4 The student will investigate and understand basic characteristics of electricity. Key concepts include

a) electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy.

Builds To: High school science courses require students to have an understanding of energy transformations.

B

14



Which of these forms of energy can be produced by passing the magnet through the coil of wire?

F Nuclear energy
G Light energy
H Chemical energy
J Electrical energy

Instruction: Provide students an opportunity to investigate electrical energy formed by passing a magnet through a coil of wire.

Science Test

GRADE

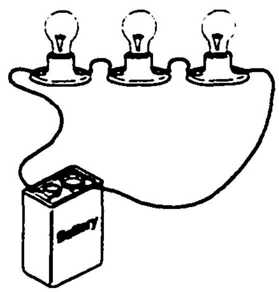
A. Standard of Learning: 6.4 The student will investigate and understand basic characteristics of electricity. Key concepts include

d) circuits can be parallel or series.

Builds To: High school science requires students to understand circuits for use in experiments.

A

15



Which of these best describes this type of circuit?

A Alternating
B Parallel
C Series
D Open

Instruction: Provide students an opportunity to investigate a series circuit.

B. Standard of Learning: 6.5 The student will investigate and understand that all matter is made up of atoms. Key concepts include

a) atoms are made up of electrons, protons, and neutrons.

Builds To: High school science courses require students to understand atoms and their makeup.

B

16 Which of these have a positive charge and are found in the nucleus of an atom?

F Neutrons
G Protons
H Electrons
J Elements

Instruction: Provide students an opportunity to investigate the protons of a nucleus.

Science Test

GRADE

A. Standard of Learning: 6.6 The student will investigate and understand how to classify materials as elements, compounds, or mixtures. Key concepts include

a) mixtures can be separated by physical processes.

Builds To: High school science courses require students to understand how elements, compounds, and mixtures differ.

A

17 A student first dissolves sugar in water, then evaporates the water to make rock candy. The sugar water is an example of —

A an atom
B an element
C a mixture
D a compound

Instruction: Provide students an opportunity to investigate the separation of sugar and water in an experiment.

B. Standard of Learning: 6.7 The student will investigate and understand that matter has physical and chemical properties and can undergo change. Key concepts include

a) physical changes.

Builds To: High school science courses require students to understand physical changes that occur in matter.

B

18 Which of these is the best example of physical change?

F A match burning
G A cake baking
H A marshmallow roasting
J A candy bar melting

Instruction: Provide students an opportunity to investigate physical changes in matter.

Science Test

GRADE

A. Standard of Learning: 6.7 The student will investigate and understand that matter has physical and chemical properties and can undergo change. Key concepts include

b) changes in chemical composition, including oxidation reactions (rusting and burning), photosynthesis, and acid-base neutralization reactions.

Builds To: High school science courses require students to understand chemical changes that can occur in matter.

A

19 The process of iron combining with oxygen to form rust is considered a chemical change because rust has —

A properties that differ from both iron and oxygen
B the same chemical composition as iron
C a very high melting point
D greater chemical reactivity than oxygen

Instruction: Provide students an opportunity to identify rusting as an example of a chemical change.

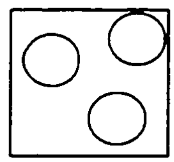
B. Standard of Learning: PS.2 The student will investigate and understand the basic nature of matter. Key concepts include

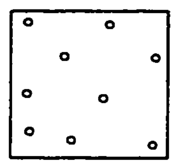
a) the particle theory of matter.

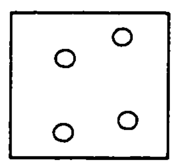
Builds To: High school science courses require students to understand the basic nature of matter.

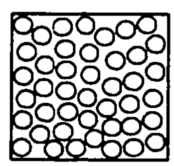
B

20 Some students were building models of solids, liquids, and gases by gluing plastic balls to a sheet of cardboard. Which of their models best shows the particles in a solid?

F 

G 

H 

J 

Instruction: Provide students an opportunity to investigate what a particle model for a solid looks like.

Science Test

GRADE

A. Standard of Learning: PS.2 The student will investigate and understand the basic nature of matter. Key concepts include

b) elements, compounds, mixtures, acids, bases, salts, organic, inorganic, solids, liquids, and gases.

Builds To: High school science courses require students to understand the basic nature of a compound.

A

21 Which of these is a compound?

A Oxygen in the air
B Liquid nitrogen
C Neon in lights
D Carbon dioxide gas

Instruction: Provide students an opportunity to investigate compounds.

B. Standard of Learning: PS.2 The student will investigate and understand the basic nature of matter. Key concepts include

c) characteristics of types of matter based on physical and chemical properties.

Builds To: High school science courses require students to understand the physical and chemicai properties of matter.

B

22 Some thermometers contain alcohol. Alcohol is used in thermometers because it —

F is soluble in water
G is a clear gas when it evaporates
H expands and contracts easily
J has a high density

Instruction: Provide students an opportunity to investigate the characteristics of alcohol.

Science Test

GRADE

A. Standard of Learning: PS.3 The student will investigate and understand various models of atomic structure including Bohr and Cloud (quantum) models.

Builds To: High school science courses require students to understand models of atomic structure.

A

23 Which of these is most responsible for chemical reactions?

A Electrons in the nucleus of the atoms
B Electrons in the highest occupied energy level of the atoms
C Electrons closest to the nucleus of the atoms
D Electrons traveling the fastest toward the center of the atoms

Instruction: Provide students an opportunity to investigate atomic structure and its relation to chemical reactions.

B. Standard of Learning: PS.5 The student will investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter and Energy. Key concepts include

c) chemical changes (types of reactions, reactants and products, and balanced equations).

Builds To: Students will continue to use balanced equations throughout future science courses, especially Chemistry.

B

21 $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

In this reaction, the products are —

F CH_4 and $2O_2$
G CH_4 and CO_2
H $2O_2$ and $2H_2O$
J CO_2 and $2H_2O$

25 Hydrochloric acid reacts with sodium hydroxide to release water and sodium chloride. Which of these is a balanced chemical equation for this reaction?

A $2HCl + NaOH \rightarrow 2H_2O + NaCl$
B $HCl + NaOH \rightarrow H_2O + NaCl$
C $HCl + 2NaOH \rightarrow H_2O + 2NaCl$
D $2HCl + 2NaOH \rightarrow H_2O + 2NaCl$

Instruction: Provide students an opportunity to write balanced chemical equations for reactions and identify reactants and products in a chemical reaction.

Science Test

GRADE

A. Standard of Learning: PS.7 The student will investigate and understand temperature scales, heat, and heat transfer. Key concepts include

a) absolute zero, phase change, freezing point, melting point, boiling point, conduction, convection, radiation, vaporization, and condensation.

Builds To: Students will continue to apply their knowledge of vaporization throughout high school science.

A

26 Mercury can vaporize if heated. This means that with enough heat mercury can —

F be destroyed
G become water vapor
H be changed into a gas
J change from a liquid to a solid

Instruction: Provide students an opportunity to investigate vaporization.

B. Standard of Learning: PS.8 The student will investigate and understand characteristics of sound and technological applications of sound waves. Key concepts include

b) technological applications of sound.

Builds To: Students will continue to apply their knowledge of measuring sound waves throughout high school science courses.

B

27 Which of these uses sound waves to measure the distance between objects underwater?

A Radar
B Sonar
C Lasers
D Radio

Instruction: Provide students an opportunity to investigate a variety of technological devices, including sonar, that measure sound waves including sonar.

Science Test

GRADE

A. Standard of Learning: PS.10 The student will investigate and understand scientific principles and technological applications of work, force, and motion. Key concepts include

a) work, force, mechanical advantage, efficiency, power, horsepower, gravitational force, speed/velocity, mass/weight, Newton's three laws of motion, acceleration.

Builds To: Students will continue to apply the principles of work throughout high school science.

A

28 According to the scientific definition of work, which of these best shows that work is being done?

F A lamp hanging from a ceiling
G A man pushing against a concrete wall
H A car being towed down a street
J A rocket drifting through space

Instruction: Provide students an opportunity to apply the scientific definition of work to real-life situations.

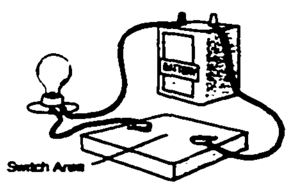
B. Standard of Learning: PS.11 The student will investigate and understand basic principles of electricity and magnetism. Key concepts include

a) static, current, circuits.

Builds To: Students will continue to work with conductors, particularly in high school science courses.

B

29



Light Produced by Closed Circuit

Switch Material	Light Produced			
	Test 1	Test 2	Test 3	Test 4
Glass [illegible]	None	None	None	None
Steel Nail	Bright	Dim	Very Bright	Bright
Aluminum Foil	Very Bright	Bright	Very Bright	Very Bright
Pencil Lead	Dim	Dim	Dim	Dim

According to these data, which material is the poorest electrical conductor?

A Glass
B Steel
C Aluminum
D Pencil lead

Instruction: Provide students an opportunity to analyze data in a table to determine the poorest conductor of electricity.

Science Test

GRADE

Reporting Category: Life Systems

A. Standard of Learning: LS.2 The student will investigate and understand that all living things are composed of cells. Key concepts include

a) cell structure and organelles (cell membrane, cell wall, cytoplasm, vacuole, mitochondrion, endoplasmic reticulum, nucleus, and chloroplast).

Builds To: Students will continue to study cells in high school science courses.

A

30 **The various organized structures present in the cytoplasm are called organelles. Which of the following organelles is responsible for the release of energy to support cell activities?**

- F Mitochondrion
- G Endoplasmic reticulum
- H Vacuole
- J Nucleus

Instruction: Provide students an opportunity to investigate the function of mitochondrion.

B. Standard of Learning: LS.2 The student will investigate and understand that all living things are composed of cells. Key concepts include

b) similarities and differences between plant and animal cells.

Builds To: Students will continue to apply the concept of photosynthesis, especially in high school science courses.

B

31 **Animals and plants get their food in different ways. Animals usually ingest their food, while plants must produce their own food. The process through which plants produce their food is called —**

- A respiration
- B photosynthesis
- C pollination
- D germination

Instruction: Provide students an opportunity to investigate photosynthesis.

Science Test

GRADE

A. Standard of Learning: LS.2 The student will investigate and understand that all living things are composed of cells. Key concepts include

c) development of cell theory.

Builds To: Students will continue to work with cell theory, especially in high school science courses.

A

32 **Many ideas concerning cells have been proven and incorporated into the cell theory. Which of the following is *not* part of the cell theory?**

F All living things are composed of one or more cells
G All cells come from other cells.
H All functions may be carried out by cells
J All cells reproduce through meiosis

Instruction: Provide students an opportunity to investigate the cell theory.

B. Standard of Learning: LS.3 The student will investigate and understand that living things show patterns of cellular organization. Key concepts include

a) cells, tissues, organs, and systems.

Builds To: Students will continue to work with cellular organization in high school science courses.

B

33 **Which of these structures is made up of all of the others?**

A Cells
B Tissues
C Systems
D Organs

Instruction: Provide students an opportunity to investigate the hierarchy within cellular organization.

Science Test

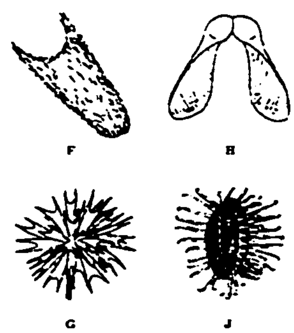
A. Standard of Learning: LS.5 The student will investigate and understand classification of organisms. Key concepts include

a) differences in number, color, size, shape, and texture of external and internal structures.

Builds To: Students will continue to work with organisms and how external structures and shapes affect classification of organisms in high school science courses.

A

34 Seeds come in different shapes to help them travel away from the parent plant. Some seeds stick to the fur of animals as they walk close to plants, while other seeds get blown away by the wind. Which of the following seeds probably travels by wind?



35 The hard outer covering of a lobster is called the —

A abdomen
B spine
C vertebra
D exoskeleton

Instruction: Provide students an opportunity to investigate the shape of seeds and the effect the shape has on the travel of the seed; and to investigate the external structure of a lobster.

B. Standard of Learning: LS.13 The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key concepts include

b) characteristics that can and cannot be inherited.

Builds To: Students will continue to work with genetics in high school science courses.

B

36 Which of the following traits of a corn plant is *least* influenced by the environment?

F Height
G Root structure
H Color of kernels
J Number of ears produced

Instruction: Provide students an opportunity to investigate characteristics that can and cannot be inherited in corn.

Science Test

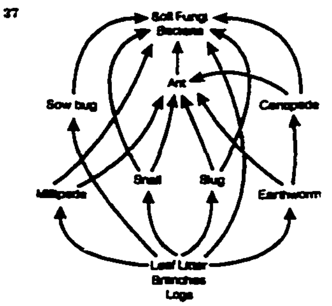
GRADE

Reporting Category: Ecosystems

A. Standard of Learning: 6.9 The student will investigate and understand that organisms depend on other organisms and the nonliving components of the environment. Key concepts include

b) food webs and food pyramids.

Builds To: Students will continue to work with food webs in high school science courses.



The diagram shows a simple food web of organisms on a forest floor. Which of these is *most* dependent on the earthworm for its food supply?

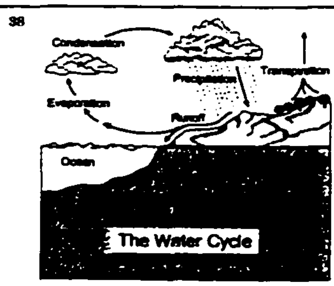
A Slug
B Centipede
C Ant
D Bacteria

Instruction: Provide students an opportunity to analyze a food web.

B. Standard of Learning: 6.9 The student will investigate and understand that organisms depend on other organisms and the nonliving components of the environment. Key concepts include

c) cycles (water, carbon dioxide/oxygen, nitrogen).

Builds To: Students will continue to work with the water cycle in high school science courses.



Most of the water in the air comes from —

F precipitation
G condensation
H evaporation
J transpiration

Instruction: Provide students an opportunity to analyze a water cycle diagram.

Science Test

GRADE

A. Standard of Learning: LS.9 The student will investigate and understand interactions among populations in a biological community. Key concepts include

d) symbiotic relationships and niches.

Builds To: Students will continue to work with niches in high school science courses.

A

39 **Which of these best describes the niche of a lion?**

A Parasite
B Prey
C Predator
D Producer

Instruction: Provide students an opportunity to investigate niches.

B. Standard of Learning: LS.10 The student will investigate and understand how organisms adapt to biotic and abiotic factors in a biome. Key concepts include

b) characteristics of land, marine, and freshwater biomes.

Builds To: Students will continue to work with biomes in high school science courses.

B

40 **Which biome is most suitable for raising crops such as corn, wheat, and oats?**

F A desert
G A taiga
H A grassland
J A tropical rain forest

Instruction: Provide students an opportunity to investigate the characteristics of plants and animals that inhabit a biome.

Science Test

GRADE

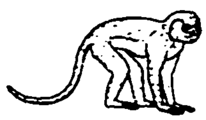
A. Standard of Learning: LS.10 The student will investigate and understand how organisms adapt to biotic and abiotic factors in a biome. Key concepts include

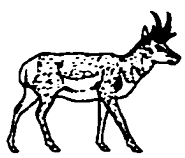
c) adaptations that enable organisms to survive within a specific biome.

Builds To: Students will continue to work with biomes in high school science courses.

A

41 Which of these is best adapted to a grassland biome?

A


B


C


D


Instruction: Provide students an opportunity to investigate adaptations needed for a grassland biome.

B. Standard of Learning: LS.11 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time (daily, seasonal, and long term). Key concepts include

b) factors that increase or decrease population size.

Builds To: Students will continue to work with ecosystems in high school science courses.

B

42 An open-air waste water treatment plant is flooded by rain. The rainwater and the waste run into a nearby creek. The organic wastes are very high in Biological Oxidation Demand (BOD) which means the bacteria in the waste need a lot of oxygen. What is the best hypothesis to explain why many fish might die as a result of this event?

F The bacteria remove the oxygen from the water.

G The bacteria create toxic wastes.

H The bacteria are eaten by the fish and are toxic.

J The bacteria eat all the food in the creek.

Instruction: Provide students an opportunity to investigate the effect of waste in water on the fish population.

Science Test

GRADE

A. Standard of Learning: LS.12 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include

d) population disturbances and factors that threaten and enhance species survival.

Builds To: Students will continue to work with population changes throughout high school science courses.

A

43 There are many factors that influence the population changes of an ecosystem. Which of these does *not* influence population size in an ecosystem?

A Birthrates of animals
B Number of animals in habitats
C An animal's weight
D The size of a habitat

44 In 1600, between 60 million and 125 million American bison roamed the plains. These bison were used by Native Americans as a primary food source, but this did not have much effect on the bison population. A few hundred years later, railroad crews and settlers moving west also depended on the bison for food. By 1889, it is estimated that less than 100 bison were left. What were the two main causes of the near-extinction of the bison?

F Disease and overhunting
G Loss of habitat and disease
H Overhunting and loss of habitat
J Loss of habitat and starvation

Instruction: Provide students an opportunity to investigate factors that influence population change and to investigate causes of extinction of species.

Science Test

GRADE

Reporting Category: Earth and Space Systems

A. Standard of Learning: 6.10 The student will investigate and understand the organization of the solar system and the relationships among the various bodies that comprise it. Key concepts include

c) the role of gravity.

Builds To: Students will continue to work with the concept of gravity in high school science courses.

A

45 The force that holds objects close to Earth is called —

A air
B ozone
C gravity
D pressure

Instruction: Provide students an opportunity to investigate the role of gravity on Earth.

B. Standard of Learning: 6.10 The student will investigate and understand the organization of the solar system and the relationships among the various bodies that comprise it. Key concepts include

d) revolution and rotation.

Builds To: Students will continue to apply the concept of revolution in high school science courses.

B

46 One complete revolution of a planet around the sun equals one —

F year
G month
H week
J day

Instruction: Provide students an opportunity to investigate revolution of planets.

Science Test

A. Standard of Learning: 6.10 The student will investigate and understand the organization of the solar system and the relationships among the various bodies that comprise it. Key concepts include

g) the cause of tides.

Builds To: Students continue to apply the cause of tides in high school science courses.

A

47 **Which of these causes tides on the Earth?**

- A The gravitational pull of the moon
- B The revolution of the Earth around the sun
- C Differences in wind speed around the Earth
- D The tilt of the Earth's axis

Instruction: Provide students an opportunity to investigate the cause of tides.

B. Standard of Learning: 6.11 The student will investigate and understand public policy decisions relating to the environment. Key concepts include

c) cost/benefit tradeoffs in conservation policies.

Builds To: Students continue to apply knowledge of environmental policy decisions in high school science courses.

B

48 **Nuclear power plants can produce energy more cheaply and with less pollution than plants that use fossil fuels. Why are there not more nuclear power plants than plants that burn fossil fuels?**

- F There is an endless supply of fossil fuels available.
- G Nuclear fuels produce too little heat during the fission reaction.
- H A pound of a fossil fuel produces more energy than a pound of nuclear fuel.
- J The problem of disposing large amounts of nuclear waste is not resolved.

Instruction: Provide students an opportunity to investigate the conservation policies concerned with the use of nuclear power plants as energy sources compared to plants that use fossil fuels.

Science Test

GRADE

A. Standard of Learning: LS.14 The student will investigate and understand that organisms change over time. Key concepts include

c) how environmental influences, as well as genetic variation, can lead to diversity of organisms.

Builds To: Students continue to apply knowledge of genetics in high school science courses.

A

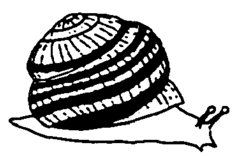
49

Probing bill   Grasping bill   Crushing bill

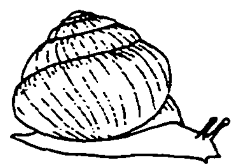
Finches found on the isolated Galapagos islands are different species with different beak sizes and shapes, but are otherwise similar to a finch species found on the South American mainland. What might be the cause of the differences in the development of the beaks of these Galapagos finches?

A The different types of food available on the islands
B The original source of the finches
C The differences in the types of nests the birds built
D The type of predators found on the islands

50

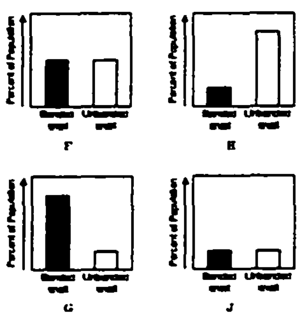


Banded snail



Unbanded snail

Fifty banded and fifty unbanded snails of the same species were released in an area where the banded snails are easily camouflaged. Which of the following best represents the population of these snails after one year?



Instruction: Provide students an opportunity to investigate how the type of food available can lead to genetic variation and to investigate how camouflaging can affect a population.

Appendix D

Teacher Consent Form

Do not use this one

CONSENT FORM FOR TEACHERS

1. **Title of Research Study.**

   A study of the effects of constructivist vs. traditional direct instruction on 8th grade physical science comprehension.

2. **Project Director.**
   Clair T. Berube (757)683-5491

3. **Purpose of the Research.**
   The purpose of this research project is to determine whether constructivist (student-centered) based instruction is more effective than direct instruction (teacher-centered) based science instruction in terms of comprehension as measured by Virginia Standards of Learning scores and comprehension measurement scores for urban 8th grade middle school science students. The study will explore these questions: how is performance on Virginia SOLs and comprehension measurement related to constructivist vs. traditional teacher practices and what are the implications for gender and race? According to studies, students who are taught with constructivist-based instruction score higher on comprehension measurement and have better attitudes towards science. Also, achievement is higher in constructivist classrooms that include components such as cooperative groups, and child-centered instruction.

4. **Procedures for this Research.**
   Stage 1:
   Every 8th grade science teacher in Norfolk, Virginia, will receive a copy of The Revised Constructivist Learning Environment Survey (CLES, a Likert-type survey) that will determine the teacher's perception of the presence of selected components of a constructivist environment (personal relevance, scientific uncertainty, critical voice, shared control and student negotiation). The survey will be given to a total of 24 teachers. Contact with school principals will precede placement of CLES surveys into teacher's boxes. They will be told that all answers will be confidential.
   Stage 2:
   The CLES survey scores will be used by the researcher to determine which classrooms are traditional and which are constructivist. From the middle schools, 8 classrooms will be chosen based on their scores. Upon selection of those 8 classrooms, the researcher will observe the classrooms to determine if indeed the classes are either traditional or constructivist. The researcher will visit the eight classrooms at other predetermined times throughout the semester.
   Stage 3:
   Upon selection of the eight classrooms, the teachers of each class will administer the 8th grade Virginia Standards of Learning tests to the students in May, 2001. Within a week, the teachers will administer the comprehension measurement as a follow-up to

the SOL test. The results of the SOL tests and the comprehension measurement will be compared to determine if comprehension is greater with those students taught in the constructivist classrooms versus the traditional classrooms.

5. **Potential Risks of Discomfort.**

There are no potential risks of discomfort other than those normally found in a science classroom. Teachers will fill out one instrument, a 30-question survey. If you wish to discuss these or any other discomforts you may anticipate, you may call the Project Director listed in #2 of this form.

6. **Potential Benefits to You or Others.**

If results indicate higher student achievement comes with increased use of instruction that is informed by constructivism, then this would be of value to the teachers and students. Possible application of the constructivist environment, brought about by constructivist informed pedagogy, to other areas of the curriculum could be the basis for further research.

7. **Alternative procedures.**

Generally, there will be little alternative procedures to this research. The administration of a follow-up exam consisting of short answer items about a week following the SOLs is the only procedure. Your participation is entirely voluntary, and you may withdraw consent and terminate participation at any time without consequence, although your participation is extremely valuable and important for the betterment of education. Through your participation, you are forever among the elite educators whose efforts add to the knowledge base in educational research. Because of the low numbers of 8th grade science classrooms, it is very important that you participate in the study.

8. **Protection of confidentiality.**

Scores from the test and information from interviews and classroom observations will be immediately coded by the principal investigator to protect anonymity. A code name for the teacher will be used unless the teacher wishes otherwise. Even the principal of the school, while being informed of the test results, will not know which teacher's classrooms are which.

I have been fully informed of the above-described procedure with its possible benefits and risks, and I have given permission for participation in this study.

______________________	______________________	________
Signature of Subject	Name of Subject (Print)	Date
______________________	______________________	________
Signature of Person Obtaining Consent	Name of Person Obtaining Consent (Print)	Date

Appendix E

Principal Consent Form

March 21, 2001

Ms.
Blair Middle School

Dear Ms.,

As a doctoral candidate at Old Dominion University, I am researching a theory of cognition that may improve science education in middle schools. I would like to gather data from SOL scores from your 8th grade science students who consent to participate. I would greatly appreciate your permission to do so.

Included are the forms from Norfolk Public Schools and Old Dominion University granting permission to carry out this research. Since there are a low number of 8th grade science classrooms in the city of Norfolk, it is very important that every middle school participate. Your permission will be much appreciated. Enclosed is a return envelope that requires no postage.

Sincerely,

Clair T. Berube
(683-5491)

Approved by ____(middle school principal)

Appendix F

Descriptive Statistics for CLES Items by Teacher Type

Appendix F

Descriptive Statistics for CLES items by Teacher Type(TT): Constructivist (C), Neutral (N), and Traditional (T).

Item	TT	Mean	SD	n
Item 1: Students learn about the world outside of school.				
	C	4.40	.548	5
	N	3.40	1.949	5
	T	3.67	.577	3
Item 2: Students' new learning starts with problems about the world outside of school.				
	C	3.80	1.059	5
	N	3.00	1.732	5
	T	3.33	.577	3
Item 3: Students learn how science can be part of their out-of-school life.				
	C	4.60	.894	5
	N	3.40	1.949	5
	T	4.00	.000	3
Item 4: Students get a better understanding of the world outside of school.				
	C	4.00	1.000	5
	N	4.20	.837	5
	T	3.33	.577	3
Item 5: Students learn interesting things about the world outside of school.				
	C	4.60	.548	5
	N	4.20	.447	5
	T	2.00	1.000	3
Item 6: What students learn has nothing to do with their out-of-school life.				
	C	2.60	1.517	5
	N	1.40	.548	
	T	2.00	1.155	3
Item 7: Students learn that science cannot provide perfect answers to problems.				
	C	4.00	1.000	5
	N	3.00	1.414	5
	T	3.00	.000	3

Appendix F con't.

Descriptive Statistics for CLES items by Teacher Type(TT): Constructivist (C), Neutral (N), and Traditional (T).

Item	TT	Mean	SD	n
Item 8: Students learn that science has changed over time.				
	C	4.40	.837	5
	N	3.60	.548	5
	T	4.00	.000	3
Item 9: Students learn that science is influenced by people's values and opinions.				
	C	4.20	.837	5
	N	3.00	.707	5
	T	3.46	1.127	3
Item 10: Students learn about the different sciences used by people in other cultures.				
	C	2.80	1.095	5
	N	3.00	1.414	5
	T	3.00	1.115	3
Item 11: Students learn that modern science is different from the science of long ago.				
	C	4.20	.837	5
	N	3.00	.000	5
	T	2.67	.577	3
Item 12: Students learn that science is about inventing theories.				
	C	3.80	.837	5
	N	3.80	.837	5
	T	3.67	.577	3
Item 13: It's ok for students to ask me "who do I have to learn this?"				
	C	4.80	.447	5
	N	3.80	1.304	5
	T	3.33	.577	3
Item 14: It's ok for students to question the way I'm teaching.				
	C	4.20	.837	5
	N	4.00	.707	5
	T	3.00	.000	

Appendix F con't.

Descriptive Statistics for CLES items by Teacher Type(TT): Constructivist (C), Neutral (N), and Traditional (T).

Item	TT	Mean	SD	n
Item 15: It's ok for students to complain about activities that are confusing.				
	C	4.20	.837	5
	N	3.60	.548	5
	T	3.00	1.000	3
Item 16: It's ok for students to complain about anything that prevents them from learning.				
	C	4.60	.548	5
	N	4.40	.894	5
	T	2.67	.577	3
Item 17: It's ok for students to express their opinions.				
	C	4.80	.447	5
	N	5.00	.000	5
	T	3.67	1.155	3
Item 18: It's ok for students to speak up for their rights.				
	C	4.40	.894	5
	N	4.80	.447	5
	T	3.33	.577	3
Item 19: Students help me to plan what they're going to learn.				
	C	3.40	.894	5
	N	3.00	.707	5
	T	2.00	1.000	3
Item 20: Students help me to decide how well they are learning.				
	C	4.20	.837	5
	N	3.40	.548	5
	T	3.00	.000	3
Item 21: Students help me to decide which activities are best for them.				
	C	3.80	1.095	5
	N	3.80	.447	5
	T	2.00	1.000	3

Appendix F con't.

Descriptive Statistics for CLES items by Teacher Type(TT): Constructivist (C), Neutral (N), and Traditional (T).

Item	TT	Mean	SD	n
Item 22: Students help me to decide how much time they spend on activities.				
	C	3.60	.894	5
	N	3.60	.894	5
	T	2.67	1.528	3
Item 23: Students help me to decide which activities they do.				
	C	3.60	.548	5
	N	3.40	.548	5
	T	2.33	1.155	3
Item 24: Students help me to assess their learning.				
	C	4.00	1.000	5
	N	3.20	.837	5
	T	2.33	1.155	3
Item 25: Students get the chance to talk to other students.				
	C	4.60	.548	5
	N	4.40	.548	5
	T	2.33	1.155	3
Item 26: Students talk with other students about how to solve problems.				
	C	4.40	.548	5
	N	3.80	.447	5
	T	3.67	.577	3
Item 27: Students explain their ideas to other students.				
	C	4.40	.548	5
	N	4.20	.447	5
	T	3.33	.577	3

Appendix F con't.

Descriptive Statistics for CLES items by Teacher Type(TT): Constructivist (C), Neutral (N), and Traditional (T).

Item	TT	Mean	SD	n
Item 28: Students ask other students to explain their ideas.				
	C	4.00	.707	5
	N	3.60	.548	5
	T	3.00	1.000	3
Item 29: Students ask each other to explain their ideas.				
	C	4.00	.707	5
	N	3.40	.548	5
	T	3.33	.577	3
Item 30: Students explain their ideas to one another.				
	C	4.00	.707	5
	N	4.20	.447	5
	T	3.33	.577	3

Note: Lickert Scale items ranged from 1-5, 1 being most traditional, 5 being most constructivist.

Appendix G

Descriptive Statistics of Dependent Measures

Appendix G

Descriptive Statistics of Dependent Measures: Standards of Learning (SOL) and Higher-Order Skills scores (HOS), by Teacher Type (TT), Gender (G), and Ethnicity(E).

		E	G	TT	M	SD
SOL	Total			Const.	416.52	30.902
				Mixed	417.15	33.507
				Trad.	428.30	47.981
				Total	421.18	38.938
		Minor.				
			F	Const.	465.54	45.465
				Mixed	450.37	30.856
				Total	457.17	38.143
			M	Const.	447.00	75.509
				Mixed	448.85	31.861
				Total	448.20	49.421
		Total		Const.	446.82	52.909
				Mixed	449.69	30.753
				Total	448.28	42.716
		Caucasian				
			F	Const.	450.88	50.885
				Mixed	469.44	25.880
				Total	460.71	39.484
			M	Const.	478.00	61.942
				Mixed	470.38	38.719
				Total	473.64	47.940
		Total		Const.	446.29	49.973
				Mixed	469.88	31.480
				Total	456.07	44.393
HOS	Total			Const.	38.30	22.520
				Mixed	31.00	20.905
				Trad.	49.18	18.951
				Total	40.16	21.857
	Minority					
			F	Const.	56.31	29.318
				Mixed	49.69	26.501

Appendix G (con't).

Descriptive Statistics of Dependent Measures: Standards of Learning (SOL) and Higher-Order Skills scores (HOS), by Teacher Type (TT), Gender (G), and Ethnicity(E).

E	G	TT	M	SD
		Total	52.66	27.497
	M	Const.	22.71	25.369
		Mixed	38.77	32.205
		Total	27.00	24.464
Total		Const.	38.25	26.714
		Mixed	60.67	37.101
		Total	50.12	33.667
Caucasian	F	Const.	38.25	26.714
		Mixed	60.67	37.101
		Total	50.12	33.667
	M	Const.	32.00	24.666
		Mixed	64.50	21.468
		Total	50.57	27.581
Total		Const.	28.88	25.027
		Mixed	62.47	29.896
		Total	42.80	31.598

Note: Score Range SOL =(0-600), HOS=(0-100).
M=Mean, SD=Standard Deviation, Trad.=Traditional, Const.= Constructivist, Min.=Minority.

VITA

Clair T. Berube was born in Norfolk, Virginia, to Barbara and Clay Thompson on May 6, 1961. She earned her Bachelor of Arts in Psychology from Virginia Wesleyan College in 1983. She earned her Bachelor of Science in Education from Old Dominion University in 1990, and Masters of Science in Education from Old Dominion University in 1997.

Ms. Berube taught as a middle-school science teacher both in public and private schools for five years. As a graduate assistant and instructor at Old Dominion University, she taught science methods courses to undergraduates and graduates.

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