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EVALUATION OF THE EFFECTIVENESS OF THE METHOD  
USED TO TEACH CRITICAL THINKING SKILLS

by  
Kristen May

A Thesis

Submitted in partial fulfillment of the requirements of the  
Masters of Arts Degree  
Of  
The Graduate School  
at  
Rowan University  
4/15/2004  
Date

Approved by

Professor

Date Approved

April 15, 2004

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ABSTRACT  
Kristen L. May

EVALUATION OF THE EFFECTIVENESS OF THE METHOD  
USED TO TEACH CRITICAL THINKING SKILLS

2003/04

Dr. Ted Johnson  
Masters of Arts in Educational Leadership

The purpose of this study was to determine the effectiveness of teaching critical thinking skills through the infusion method as used by the Cinnaminson School District's Science Department. With the changing demands of society there comes a need for change in the preparation of students for the future that will be theirs. The sample population for this study was the one hundred and seven of the two hundred and forty freshman enrolled in Cinnaminson High School in the 2003-2004 school year who were taking college prep level earth science. Students were evaluated based on their performance on six activities designed to measure their ability to apply critical thinking skills to problem solving situations. Students demonstrated inconsistent results on activities requiring critical thinking skills. Statistical analysis, including tests of significance, indicated that there was no statistically significant improvement in their results on activities designed to evaluate student use of critical thinking skills in problem-solving situations. Implications for improving the method of instruction of critical thinking skills are discussed.

MINI-ABSTRACT

Kristen L. May

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2003/04

Dr. Ted Johnson

Masters of Arts in Educational Leadership

The purpose of this study was to determine the effectiveness of teaching critical thinking skills through the infusion method as used by the Cinnaminson School District's Science Department. The data collected in this study revealed that there was no statistically significant improvement in students' scores on activities requiring critical thinking skills as a result of the instruction of critical thinking skills through the infusion method.

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Finally, I would like to thank my parents. It has been a very long and often times very difficult journey for me to reach this stage in my life. There was a time that I did not believe I would be able to accomplish the many things I have so far in my life. They stood by my side during the difficult times and I am just happy that they are able to share this accomplishment with me.

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## CHAPTER 1

### Introduction

#### Focus of the Study

Society is changing at an almost incomprehensible speed. Discoveries and advances in science and technology are occurring all the time. The vast majority of these advances and discoveries are improving the quality of life of our society. The rapidly changing world has created an educational crisis in our nation. Margaret Mead described the situation facing education with the following statement, “We are now at a point where we must educate our children in what no one knew yesterday, and prepare our schools for what no one knows yet.”

It is the responsibility of the state to develop and maintain its educational system. Each state is facing the same crisis; the educational system in place may not be preparing today’s students to handle their future. New Jersey has developed a multi-faceted plan to address the changing needs of the students. One part of that plan is embodied in The New Jersey Core Curriculum Contents Standards. The New Jersey Core Curriculum Content Standards (New Jersey Department of Education, 1996) comprise a body of factual knowledge that must be understood by all students of science. The standards reach beyond this body of information and focus on what is referred to in the standards as “the habits of mind”. According to the standards “the habits of mind” refer to a set of skills to be mastered (New Jersey Department of Education, 1996). These skills are sometimes referred to as higher order thinking skills or critical thinking skills. Some may refer to them simply as problem-solving skills.



Regardless of the name given to them, these skills will help students overcome the fact that much of the technology and information being passed to them will be revised or obsolete before they are mature, working adults. These are skills that will enable students to continually learn from their environment and new experiences they encounter (New Jersey Department of Education, 1996). The students in the Cinnaminson School District have difficulty effectively using these skills to solve problems. This study will examine the effectiveness of the current pedagogical method used to develop students' ability to use critical thinking skills in problem-solving situations.

### Purpose of the Study

The purpose of this study was to determine the effectiveness of teaching the use of critical thinking skills through the infusion method using a case study method. The results of this study determined if students' abilities to apply these skills in problem-solving situations improved when taught to use critical thinking skills primarily through the infusion method. At this stage of the research, the evaluation of the teaching of critical thinking skills through the infusion method to improve critical thinking skills in the students will be generally defined as the evaluation of the use of the infusion method for teaching critical thinking skills. This study was designed to answer the question: How effective is the infusion method, the educational approach currently used by the Cinnaminson Public School District's science department, for teaching the application of critical thinking skills? Other sub-questions this study was designed to answer include: Do students in the Cinnaminson School District have difficulty applying critical thinking skills in problem-solving situations? Which critical thinking skills do students in the

district have the most difficulty applying? How can the improvement in the application of critical thinking skills by students be measured?

### Definitions

- Case study method- in-depth study of a single or a few programs, events, activities, groups, or other entities defined in terms of time and place using multiple methods of data collection.
- Cognition- the act or process of knowing, including both awareness and judgement.
- Constructivists- educators who believe children learn through a process of designing, inventing, and experimenting within their own environment.
- Core Curriculum Content Standards for Science- a list of ten standards and associated strands which reflect developmentally appropriate content and skills students should master in their science education.
- Critical thinking skills- context-free, open-ended, sequential cognitive processes that allow students to transform information in a strategic manner.
- Decontextualization- the process of removing from context or content.
- Flynn Effect- increase in I.Q. scores from one generation to the next for all countries for which data exists.
- Grade Eight Proficiency Assessment- an assessment designed to determine how well students are mastering the rigorous standards. It is administered in the eighth grade and consists of both multiple choice and open-ended questions.
- High School Proficiency Assessment- an assessment designed to determine how well students have mastered the Core Curriculum Content Standards in their

educational career. Presently it consists of a mathematics and language arts literacy component. It is one of the requirements for high school graduation. It is administered in the eleventh grade, with two more opportunities to take the exam if a student fall into the partially proficient category.

- IEP- Individual Educational Program. An educational program designed to specify the needs of special education students in order for the to succeed in the classroom.
- Inference- the act of passing from one statement considered to be true to another statement whose truth is believed to follow from the former.
- Infusion method- pedagogical method in which critical thinking skills are taught embedded within the confines of the existing curriculum.
- Metacognition- the process of reflection on thinking; thinking about the process of thinking.
- Problem solving skills- context-free, open-ended, sequential cognitive processes that allow students to transform information in a strategic manner. Another name for critical thinking skills.
- Scholastic Assessment Test- a three hour exam which testing verbal and mathematical reasoning skills. It is often used as one of the indicators for colleges in the admissions process.
- TIMSS- Trends in International Mathematics and Science Study. A large scale study that attempts to follow patterns in mathematics and science education.

### Limitations of the Study-

The findings and conclusions of this study will only be relevant to the science department in Cinnaminson High School. The teachers involved will be only those teachers who teach science in Cinnaminson High School. Issues that will be addressed will be exclusive to the Cinnaminson School District and to its science curriculum. This study can not be replicated in another setting because it is based on problems inherent to the science curriculum and the student population in the Cinnaminson School District. The results of this study are only applicable to the students in the Cinnaminson School District taking science courses in the 2003-2004 school year.

### Setting of the Study

Cinnaminson is a township located in Burlington County, New Jersey. The township of Cinnaminson derives its name from a variation of a Leni-Lenape Indian word “Senamenging” which means “sweet water”. Sweet water was apparently referring to the sugar maple trees that grew along the Delaware River in this location (Cinnaminson Township, 2003). The township has evolved from a farming community to an established suburban community with a population of approximately 14,595 and approximately 5,099 residential properties (Cinnaminson Township, 2003). Cinnaminson is located directly across from the far northeast section of Philadelphia, Pennsylvania. The National Center for Educational Statistics (2003) refers to Cinnaminson as a location in an urban fringe of a large city. Two active farms still remain producing fruits and vegetables which are sold locally. Cinnaminson is now home to an industrial complex which is responsible for the manufacturing of glass, powdered iron products, and hard discs activator arms (Cinnaminson Township, 2003).

Cinnaminson can be generally described as a white collar community. Thirty-nine percent of the working civilian population is employed in management, professional, and related occupations. Thirty-four percent of the working population is employed in sales and office occupations. There is great diversity in socioeconomic status within the community. This is evident in the great range in household incomes, 106 homes with incomes less than \$10,000 and 197 homes with incomes greater than \$200,000, but the median household income is \$68,474 (U.S. Census Bureau, 2003).

Cinnaminson boasts of tremendous loyalty of residents to the community. This is evident in the pattern that has emerged in the record of student mobility in recent years as shown in the School Report Card. During the 1997-1998 school year, the student mobility rate in Cinnaminson was 13.8%, slightly above the state average of 13.6%. During the next school year, the student mobility rate decreased to 12.3%. There was a huge decline in student mobility in Cinnaminson during the 1999-2000 school year, falling to 2.8%. The state average was still hovering at 12.3%. Student mobility in the Cinnaminson School District stabilized in the next two school years at 3.6% which was well below the 12% state average (New Jersey Department of Education, 2003).

The relationship between the school district and the community is described by a long time administrator as an agreeable relationship. The community supports the school district in various ways but not always monetarily through the passage of the school budget. There has been no certainty in whether the budget will pass since 1968. The principal at the high school speaks of the passage of budgets relative to the superintendent at the time. Overall, in his thirty-five year tenure in the school district, he estimates that the budget has been passed 40% of the time. The budget defeat in April

2003 was the first defeat of the current superintendent and the first in five years. The turnout of voters was small, approximately 1,200 people went to the poles. The large senior citizen population is thought to be responsible for the defeat.

The Cinnaminson Home and School Association raises money for various projects and scholarships in the district. The money raised by this group is used to completely fund Project Graduation. Project Graduation is a huge event held after graduation ceremonies in a facility where there are many types of activities and great prizes for the students. Project Graduation is meant to provide students with a safe way of celebrating graduation. The Home and School Association also gives out scholarships to seniors during graduation.

The Cinnaminson Education Foundation is an organization set up to channel private sector resources to the public schools of Cinnaminson. The Foundation's purpose is to promote excellence in education by making funds available for educational needs not provided for in the budget. It was created as a non-profit organization in 1998 by community-minded business owners, professionals, and parents to enhance the education of the students. The Foundation is organized and run by volunteers and has funded grant programs totaling approximately \$20,000. The Foundation seeks to award "mini-grants" to applicants, school employees, seeking funding for programs. In determining which grants to award, they consult the superintendent regarding the needs and the direction of the district. The trustees then evaluate the applications using the input of the superintendent as guidelines.

The school, in turn, reaches out to the community in several ways. During Spirit Week, one of the competitions held between the classes is a fund raiser to support various

community programs. Near the holidays, a food drive is held in the school for the Jane Weilenbeck Foundation. The food is donated to families living in poverty in the community.

“The Mission of the Cinnaminson School District is to educate our students and to assist their development into self-motivated, multi-faceted, happy and physically fit individuals who are productive, responsible citizens” (Cinnaminson School District, 2003). This is the mission statement which can be found on the district’s website homepage. No matter what individual students’ future plans are, the primary goal in Cinnaminson is to make them educated, responsible citizens. This philosophy emanates from all schools in the district.

The school district consists of the grade levels pre-kindergarten through twelfth grade. These grade levels are distributed throughout four school buildings. According to the National Center for Educational Statistics (2003) there were 2,553 students during the 2001-2002 school year. Four hundred and forty-seven of those students have IEPs. One hundred and ninety eight classroom teachers are employed by the district. The student to teacher ratio is 12.9 to 1 (National Center for Education Statistics, 2003).

According to the National Center for Educational Statistics (2003), the total revenue for the district for the 2001-2002 school year was \$27,014,000. This breaks down to \$10,814 per student. This contradicts the figure reported in the School Report Card which reported the per student cost to be \$9,407 (New Jersey Department of Education, 2003). A very large percentage of the revenue came from local sources. The remainder of the revenue broke down to 31% coming from the state and 2% of the revenue coming from the federal government (National Center for Education Statistics, 2003).

According to the 2001-2002 School Report Card issued by the New Jersey Department of Education (2003), the district's administration has a median of twenty-seven years experience with a median salary of \$83,919. This is below the state median of \$92,904 for the state median of twenty-six years. A similar situation can be observed in the salaries of the faculty. The district's median salary was \$47,652 for ten years of experience. The state median for years of experience and salary were 12 years and \$50,147, respectively.

After a recent, summer of 2001, re-organization of the lower grades, New Albany School is now home to kindergarten through second grade. The National Center for Educational Statistics (2003) cited that there were 453 students enrolled in the 2001-2002 school year. The student population is evenly distributed between males and females. There is not a great deal of ethnic/racial diversity in the district. This is evident in the composition of New Albany's enrollment. Three hundred eighty-four of the four hundred fifty-three students were white. Thirty-five of the students were black. Nineteen of the students were Asian. Fifteen of the students were Hispanic. Thirty of the students enrolled in New Albany are eligible for the free lunch program and eleven of the students are eligible for reduced-priced lunch. New Albany is a Title I school.

The Rush Elementary School is larger than New Albany. Rush is home to grades three through five. According to the National Center for Education Statistics (2003), enrollment in the 2001-2002 school year was 602 students. Forty-eight classroom teachers were employed there in that school year. The student population, as in New Albany, was equally divided between males and females. The student population, when divided based on ethnic or racial background, shows a pattern similar to what was seen in



New Albany. Five hundred and thirty-four of the six hundred and two students were white, forty students were black, eighteen students were Hispanic, and ten students were Asian. Thirty-two students were free-lunch eligible and twelve students were reduced-price lunch eligible (National Center for Education Statistics, 2003).

Sixth, seventh, and eighth grades are currently located in the middle school. According to the National Center for Education Statistics (2003), fifty-four classroom teachers were employed by the middle school in 2001-2002. Six hundred and sixty-one students were enrolled in Cinnaminson Middle School for the 2001-2002 school year. Male students slightly outnumbered the female students. The middle school also shows very little diversity in race or ethnicity. Five hundred ninety-seven of the six hundred sixty-one students were white. The remainder of the student population consisted of forty black students, fourteen Hispanic students, and ten Asian students. Twenty-seven students were free lunch eligible and twenty students were reduced-price lunch eligible.

The enrollment in grades nine through twelve in the high school during the 2001-2002 school year, according to the School Report Card, was 837 students New Jersey Department of Education (2003). The National Center for Educational Statistics (2003) reports sixty-one classroom teachers were employed during the 2001-2002 school year. The student to teacher ratio was 13.6 to 1. The average class size in 2001-2002 was 21 students.

According to the School Report Card, faculty attendance at 97.3% was higher than the state average of 95.6%. During the 2001-2002 school year, 60% of the high school staff had earned a BA/BS. Thirty-nine percent of the staff had earned a MA/MS. One percent of the staff was at the PhD/EdD level (New Jersey Department of Education, 2003).

The High School Proficiency Assessment (HSPA) is a graduation requirement for “most” students in New Jersey. For the 2001-2002 school year, 85.1% of the one hundred sixty-eight general education student population scored at or above the proficient level for all sections of the assessment. This compares to the state average of students at or above the proficient level of 74.5%. As seen in the result from state percentages, more students were above the partially proficient level in language art literacy. Thirty-nine special education students took the HSPA during the 2001-2002 school year. For all sections of the assessment, 35.9% of the students were at or above the proficient level. This was higher than the 20.9% state average (New Jersey Department of Education, 2003).

During the 2001-2002 school year, 82% of students from Cinnaminson High School took the Scholastic Aptitude Test (SAT). This was higher than the state average of 77%. The average mathematics score for Cinnaminson students was 538. The state average score was 514. The average score for the district on the verbal portion of the SATs was 519. This was above the state average score on the verbal portion of the SATs of a 495 (New Jersey Department of Education, 2003).

Cinnaminson High School offers a General, College Preparatory, and Honors curriculum with a limited number of self-contained Special Education English and Mathematics classes. Cinnaminson High School is a relatively small high school. As with many small high schools, advanced classes and electives are limited. Advanced Placement classes may be offered in Physics, Chemistry, Biology, Calculus and History depending on the student enrollment in these courses each year. There are no special electives in science at this time but in the past ecology and other specialties have been

offered. The fine art and music departments have limited offerings. Three languages are offered, Spanish, French, and German. Additional foreign language teachers have been necessary due to the changes in graduation requirements. A general level Spanish I class is being added this year to accommodate students in the general classes and many of the students in the special education population. This is to be followed with a general level Spanish II class. Cinnaminson High School does offer a very productive C.I.E. The C.I.E. program is well established in the high school and offers students the opportunity to take their core academic classes in the morning and go to work in the afternoon. The school works in cooperation with many businesses to provide students with a work environment conducive to their growth and continued education. Cinnaminson also features a very successful D.E.C.A. program. Along with running the school store, students in D.E.C.A. hold other fundraisers to sponsor student competitions. The students in D.E.C.A. have been very successful in regional and national competitions.

### Significance of the Study

This study will make a contribution to the teachers in the science department, science students of Cinnaminson School District, and to the school in general. This study evaluated the current pedagogical practices of teaching critical thinking skills primarily through the infusion method. This study will provide another source of data upon which the curriculum and current pedagogical practices used in the science department can be evaluated to determine its ability to meet the changing needs of the students of Cinnaminson School District.

### Organization of the Study

The remainder of this study is organized in the following manner. Chapter 2, Literature Review, features a review of current literature that defines critical thinking skills, address different programs that have been developed to teach critical thinking skills, and strategies teachers can use to infuse critical thinking skills in their classroom. Chapter 3, Design of the Study, describes the design of the study including the instruments used to collect data, the sampling technique, the approach of data collection, and the plan for analysis of the data. Chapter 4, Presentation of the research Findings, describes the information that was collected and explains its significance. Chapter 5, Conclusion, Implications, and Further Study, discusses the conclusions that can be reached after analyzing the data, the impact of the study in relation to the growth of leadership skills of the intern, and what further studies might evolve from this study.

## CHAPTER 2

### Review of Current Literature

#### The Need

In today's information age, it is more important than ever for student to master thinking skills that will allow them to function in the 21<sup>st</sup> century. Throughout the course of history, many groups of individuals including philosophers, politicians, and educators, have been concerned with the process and practice of thinking (Cotton, 2001). "Teaching thinking" and "learning to learn" are not new ideas. The Greeks were credited with stating that improving the intellect was a prime aim of education (Valerie Wilson Scottish Council for Research in Education, 2000). John Dewey in the early 1900s recognized the need for teaching thinking skills. He expressed this by saying, "thinking is doing and we must give learners the challenge of thinking but also the challenge of doing something with their thinking" (Hollister, 1999).

Over time the purpose of education has shifted. Today government officials, business leaders, and educational administrators think of schools as a factory that is responsible for producing workers for the nation's public and private sector (Martin, 1995). In this factory model to which the many components of the educational system still conform, the children are the raw materials, the teachers are the stations which process the students as they move through the grades, and the curriculum is the machinery. After twelve years or so, the students have become marketable products (Martin, 1995). This model implies that there are specifications to be followed and the outcome is predictable. When the

results are below an acceptable level, quality control is tightened. Quality control methods include attempts to improve testing, implementing teacher accountability for every student's performance, and standardizing the curriculum. All of these quality control methods are implemented without examining the premise upon which this model is built and considering the needs of society at the time (Martin, 1995).

### The History of Teaching Thinking Skills

Throughout the history of the public educational system there have been many philosophers, politicians, and educators who have independently questioned this approach. The "banking theory of knowledge" based upon rote memorization and learning has been discredited as it has been recognized that individuals can not "store" sufficient knowledge in their memories to enable them to be productive adults (Valerie Wilson Scottish Council for Research in Education, 2000). John Dewey, in his work "How We Think," introduced the concept of reflective thought. Dewey's underlying assumption was that learning will increase relative to the degree upon which that learning is reflected (Shermis, 1999). Shermis explains that Dewey's concept of reflection is known by other names such as "critical thinking", "problem-solving", and "higher level thought."

Rubin (1994) describes Ralph Tyler's contributions to the field of education. Tyler gave more than seventy years of his life to the cause of education. Some of his accomplishments included his monumental Eight-Year Study, a founding role in the National Academy of Education, and his creation of and fourteen year directorship of the Center for Advanced Studies in the Behavioral Sciences at Stanford University. He is also known for his part in the creation of the Association for Evaluation of Educational

Achievement, his achievements as a university examiner and dean of Social Sciences at the University of Chicago, and his consultations with five presidents (Rubin, 1994). In an interview with Diana Beull Hiatt (1994), his response to the question regarding the purpose of schools embodied the theme upon which much of his work in education was based. Tyler said, “the focus of schools should be on serving the best interests of each child rather than on serving some leaders’ agenda. Schools in America should seek to develop problem-solving citizens who can actively engage in the work of a democratic society.” When Hiatt asked his views on how children learn, he made reference to John Dewey. Tyler explained that children discover details of the world through exploration, they construct their knowledge through direct experience. He felt educators must expand their space and their opportunities for learning. Tyler said his contemporary, John Dewey, advocated that teachers should encourage children to become actively engaged in discovering what the world is like (Hiatt, 1994).

### Science and Thinking

During the first half of the twentieth century, general intelligence was thought to be fixed and measurable. This line of reasoning has been discredited because I.Q. may not remain stable over time, the Flynn Effect, and intelligence is thought to be more than a set of inherited abilities (Valerie Wilson Scottish Council for Research in Education, 2000). Fixed, measurable intelligence fits well with the factory model of a school. Each child is “processed” the same way according to the same specifications and the product is only as valuable as the raw material (Valerie Wilson Scottish Council for Research in Education, 2000).

Alternative explanations of intellect and thinking have been generated by developments in cognitive psychology in the twentieth century (Valerie Wilson Scottish Council for Research in Education, 2000). The Swiss psychologist Jean Piaget claimed that all children, regardless of where they live, pass through the same sequence of well-differentiated stages in their thinking. Constructionists stress the active role of the learner in developing their own thinking. Bruner, a famous educational theorist, establishes a connection between thinking and the structuring of experiences. Vygotsky, another well known educational theorist, connected participation in collaborative activities and learning (Valerie Wilson Scottish Council for Research in Education, 2000).

Despite the repeated re-emergence of teaching thinking skills in theory and research, it still remains a distant educational approach in schools. In the 1980's and 1990's, the idea that critical thinking is integral to knowledge and understanding has finally begun to receive public expression and recognition. This is evident through the work of The National Council for Excellence in Critical Thinking. The goal of the NCECT is to articulate, preserve, and foster intellectual standards in critical thinking research, scholarship, and instruction as described by the Chair of the council Dr. Richard Paul (Paul, n.d.).

### What are Critical Thinking Skills?

The New Jersey Core Curriculum Content Standards describe what knowledge and skills students should develop in the course of their k-12 experience (New Jersey Department of Education, 1996). After reviewing the standards for the eight content areas, five cross-content workplace readiness standards were identified. One of the



identified standards is: “All students will use critical thinking skills, decision-making skills, and problem-solving skills” (New Jersey Department of Education, 1996).

Critical “thinking skills are context-free, open-ended, sequential cognitive processes that allow the students to transform information in a strategic matter” (Eggen and Kauchak, 1993). Questions employing critical thinking skills generally do not have a single correct answer. They generally have a range of acceptable answers depending on individual interpretation. Any list of critical thinking skills will vary based on the source. Eggen and Kauchak (1993) in “Learning and Teaching” begin the list with the top five levels of Bloom’s taxonomy: comprehending, applying, analyzing, synthesizing, and evaluating. They add to the list the following skills: comparing, contrasting, inferring, generalizing, controlling variables, making conclusions, classifying, summarizing, identifying irrelevant information, planning, hypothesizing, and predicting. This list is far from complete, Woolfolk (1995) identifies many of the same skills but breaks them down into three categories 1- defining and clarifying the problem, 2- judging information related to the problem, 3- solving problems and drawing conclusions. Regardless of the skill in question, the underlying assumption is that thinking, cognition, goes beyond the simple acquisition of factual knowledge. True learning requires some analysis or use of information and also some reflection on the process of thinking, metacognition (Valerie Wilson Scottish Council for Research in Education, 2000).

### Why Teach Critical Thinking Skills?

The National Council for Excellence in Critical Thinking Skills, in a Draft Statement of Principles by the Chairman of the council Dr. Richard Paul (n.d.), discusses some of the reasons for teaching critical thinking skills. The reasons he cites are in the Council’s

Founding Principles. There is a relationship between knowledge and thinking. If knowledge is to be attained in any domain, it requires critical thinking. Direct instruction in critical thinking skills should enable students to evaluate their own thoughts and actions as well as those of others. In a broader sense, Cotton (2001) explains the necessity of critical thinking skills as a necessity for responsible citizenship in a democratic society and as employability skills for a growing number of jobs. Spring (1994) describes how John Dewey also made the connection between democratic societies and critical thinking. Dewey argued that critical thinking is necessary for a democratic society to exist and he felt that critical thinking skills required a democratic society in which to be exercised (Spring, 1994). In today's ever-expanding information age and technological state, another issue arises. The Valerie Wilson Scottish Council for Research in Education (2000) addresses the more modern problems. The wealth of information available is expanding at such a rate that individuals must be taught the skills to use to effectively navigate new information as it becomes available to them throughout the course of their lives. Jobs in these modern times require employees who demonstrate comprehension and judgement in the development of new knowledge processes. Finally, today's society requires citizens who actively process and sort information from multiple sources and make judgements of its value. Cotton (2001), in her report on Teaching Thinking Skills, sums up the need for education in critical thinking skills. She states that, "if students are to function successfully in a highly technical society, then they must be equipped with lifelong learning and thinking skills necessary to acquire and process information in an ever-changing world."

### Effects on Student Outcomes

Valerie Wilson Scottish Council for Research in Education (2000) indicates that evaluation studies that attempt to determine the effectiveness of teaching critical thinking skills are inconclusive. It is difficult to make a conclusive evaluation because there are too many variables. These variables include class size, teacher experience, and resources available to the teacher (Valerie Wilson Scottish Council for Research in Education, 2000). Cotton (2001), however, states in her report that a broad, general finding is that nearly all of the thinking skills programs and practices she researched were found to have a positive impact on achievement levels of the participating students. Thinking skills instruction accelerated learning. Those studies she investigated had an experimental design with a control group and an experimental group. Generally the experimental group outperformed the control group to a significant degree (Cotton, 2001).

### Specific Programs Designed for Teaching Critical Thinking

In 1990, Nisbet and Davies identified over 30 programs designed specifically for critical thinking instruction. They suggested, however, that there were over a hundred programs in the United States alone (Valerie Wilson Scottish Council for Research in Education, 2000). There are a few international programs of significance. Feurstein's Instrumental Enrichment is one of the best known examples of a thinking skills program. This program was specifically designed for use with low-performing Israeli adolescents over 40 years ago. This was a program designed for direct instruction of methods for interpreting information and problem-solving (Cotton, 2001). The evidence of the effectiveness of this program is conflicting. There were statistically significant differences between the I.E. trained groups and control groups. This review was of four

countries, Israel, United States, Canada, and Venezuela. It included students in lower and middle social groups of mixed ability and educationally disadvantaged students (Cotton, 2001).

In her review of programs designed to teach thinking skills, Cotton (2001) describes the Somerset Thinking Skills Course. The Somerset course was developed because of Brigg's negative review of the Feurstein Instrumental Enrichment course. This course was designed to be used independently or integrated across the curriculum. It consists of several modules designed to develop the foundation for critical thinking skills. No large scale evaluation of the effects of this course on student achievement has been conducted. Smaller studies were conducted on a program that was an offshoot of the Somerset Thinking Skills Course and based on the same underlying principles. Twelve of the fourteen of those studies demonstrated significant educational benefits to the participants (Cotton, 2001).

Cotton (2001) in her review of programs also discusses The Cognitive Acceleration Through Science (CASE). CASE is a structured program that directly teaches critical thinking skills, despite being set in the context of science. CASE is based upon inductive reasoning and other concepts associated with Piaget's formal operational thinking stage. Studies on the effectiveness of this program are extremely weak. One evaluation of a group of students placed them one year ahead of a control group in science with smaller differences identified in reading and math after participating in this program (Cotton, 2001).

The Higher Order Thinking Skills (HOTS) Program is a well known program that at its inception focused on teaching higher order thinking skills to at-risk students (Pogrow,

1990). The program was designed to focus on four concepts: metacognition, inference from context, decontextualization, and synthesis of information. The curriculum of the program was designed to practice the four key concepts and focused on the process of thinking rather than on curricular objectives. In the second year of the program, students would apply the thinking skills to formal content activities. The program HOTS has grown by means of a grassroots movement. In 1988, the HOTS program received its first national recognition (Pogrow, 1990).

Pogrow (1990) states seven findings that resulted from studying the HOTS program. The first finding was that it was recognized that “a thinking skills program can improve achievement in the basic skills as much as a good remedial approach and possibly a good deal more.” Pogrow’s second finding was that “it appears that general thinking skills activities can be designed to enhance the ability of students to learn content the first time it is taught.” The third finding recognized that “at-risk students have tremendous levels of intellectual and academic potential.” It is not fully understood the learning potential of students. In his fourth finding, Pogrow recognized that it is possible to change dramatically the relationship between teachers and students. The fifth finding identified the fundamental learning problem of at-risk students as being their inability to understand “understanding.” His sixth finding was that the education profession fails to recognize that the problem of not understanding “understanding” exists. The final finding from his study was that fundamental learning problems can be eliminated if enough time and resources are made available.

### Teaching Thinking Skills Through Infusion

Classroom teachers can infuse lessons focusing on developing critical thinking skills in students through a variety of strategies. Potts (1994), in her article “Strategies for Teaching Critical Thinking”, divides the strategies for teaching critical thinking skills into three specific groups. The first group of strategies is “Building Categories.” Building categories includes all the skills involved in finding relationships, such analogies, between pieces of information. The second group of skills, “Finding Problems”, includes all the skills that are involved in determining the relevance and validity of information that could be used for structuring and solving problems. Finally the third group of skills, “Enhancing the Environment”, which includes all the skills related to finding and evaluating solutions or alternative ways of dealing with a problem. There are programs available that are designed to infuse critical thinking skills with the content of the curriculum. Strategies can also be used by teachers and activities can be built into the curriculum to teach thinking skills with the regular the content of the traditional curriculum.

### Programs for Teaching Thinking Skills Through Infusion

Programs that completely separate instruction of critical thinking skills are only one method of teaching these skills. Another method used by educators is called the infusion method. In this method, lessons on critical thinking skills are infused or embedded in the content of the regular curriculum. This can be achieved through strategies that will be discussed in a later section. One program designed to infuse critical thinking with content instruction is IMPACT, Increase Maximal Performance by Activating Critical Thinking

(Lang, 1995). IMPACT is a staff development program which models proven methods for integrating subject matter content with thinking skills instruction.

Critical Analysis and Thinking Skills (CATS) is another program designed for infusing critical thinking skills instruction with the regular content material. CATS is a program designed to teach students to apply critical thinking skills to problems and issues helping them to make more rational decisions and write persuasive essays. The goals of the programs are generally to help students 1- make more rational decisions 2- become critical readers 3- write persuasive essays 4- realize intellectual and creative potential and analyze issues and problems more effectively (Lang, 1995).

#### Strategies for Teaching Critical Thinking Skills Through Infusion

Potts (1994) discusses several generally recognized “hallmarks” of teaching thinking skills that can be used across the curriculum. The first strategy involves promoting interactions among students as they learn. She suggests that students learn critical thinking skills more in a group setting. This relationship between a group setting and learning critical thinking is also supported by a study described in Gokhale’s (1995) article “Collaborative Learning Enhances Critical Thinking.” This study was designed in part to determine if there was a significant difference in achievement on tests which consists of critical thinking questions between students learning individually and students learning collaboratively (Gokhale, 1995). Statistical analysis was performed on the results of the tests. The analysis indicated that students involved in collaborative learning did significantly better on critical thinking tests than students who studied individually (Gokhale, 1995). Gokhale made reference to a leader in education Vygotsky, who stated that students typically are capable of higher level work when they are involved in

collaborative learning than when working alone. The study described by Gokhale (1995) showed the group setting was valuable because it provided students with the opportunity to analyze, synthesize, and evaluate ideas cooperatively. The group setting also elicited reflection by students on their answers and the reasons behind their answers. The conclusion of this study was that through discussion, clarification of ideas, and evaluation of others' ideas, collaborative learning fosters the development and enhancement of critical thinking and problem-solving skills (Gokhale, 1995).

Reflection, a term first associated with John Dewey, has become synonymous with "critical thinking", "problem solving", and "higher level thinking." In the last forty years, it has been generally recognized that reflection can only take place in a classroom which features a questioning forum (Shermis, 1999). Questions which require critical thinking begin with the underlying assumption that students will not think unless they have something to think about, a problem. Shermis (1999) states that the problem students are asked to solve, in order to encourage thinking, must be real to the students. The importance of the problem must be expressed and the problem must be of importance to the student, not because the teacher or the text defines it as an important problem. Shermis (1999) outlines several general models for generating problems: 1- Asking students to devise alternative ways of presenting information. 2- Comparing different accounts of the same events, ideas, and phenomena. 3- Supplying alternative endings or different outcomes. 4- Role-playing, role reversal. 5- Deleting/ omitting information. 6- playing "what if". 7- Examining the social context of a given statement. 8- Attempting to identify assumptions.



Growws and Cebulla (2000) discussed research findings from various studies in their article “Improving Student Achievement in Mathematics, Part I: Research Findings in the ERIC Digest. In this article they describe research findings that show that through solving problems, students can learn both concepts and skills. Data from the TIMSS video study is discussed. This study reported that over 90% of class time in the U.S. in eighth grade classroom is spent practicing routine procedures and the remaining time is spent applying procedures learned to new situations. Virtually no time is spent on students creating new procedures through different experiences or analyzing new situations. Yet findings from numerous studies show that when students are given the opportunity to discover mathematical ideas and invent mathematical procedures, they are able to form a stronger connection between mathematical concepts.

Growws and Douglas’s (2000) review of research findings support the studies discussed earlier in this paper that stated students working in collaborative small groups, allowing them to interact when solving problems experienced a higher level of success. Growws and Cebulla (2000) in Part II of the series, “Improving Student Achievement in Mathematics”, added that whole-class discussion should follow any individual or group work students do in problem-solving or critical thinking. This whole-class discussion should involve presenting and discussing individual solution methods. Whole-class discussions can also be an effective tool for determining the level of student understanding and clarifying any misconceptions that have been formed.

Negeow (2001) address the educational approach of problem-based learning. Problem-based learning attempts to teach students how to learn. In this educational approach, cooperative groups of students work together to find solutions to real world problems.

More importantly, however, students develop skills to become self-directed learners. A key component of problem-based learning is the ability of students to work together to solve problems. Another key component of problem-based learning is the students' ability to use inquiry skills to seek and evaluate information related to the problem they are to solve. The third key component to problem-based learning is students' ability to think about their thinking, or the process of metacognition. Students of problem-based learning are encouraged to go beyond the given information, to reflect on learning, and to actively consider how their knowledge might apply in new situations. Problem-based learning is an educational approach designed to have students develop critical thinking skills (Negeow, 2001).

Hollister (1999) highlights one challenge teachers instructing problem-based learning face, assessment. This is a challenge for teachers grading any activity involving critical thinking. Often times there are not a single correct answers, but instead an array of correct answers depending upon student interpretation and analysis of the problems. In problem-based learning, like other activities involving critical thinking skills, the concentration is on "how" and "why" types of questions which are open to different interpretations depending upon the background knowledge and present skill level of the students.

Kerka (1992) cites five general principles and related teaching methods for integrating critical thinking skills into vocational curriculum. They are paraphrased and listed: 1- Help students organize their knowledge. 2- Build on what students already know. Build connections between new and prior knowledge. 3- Facilitate information processing by modeling problem solving through think aloud. 4- Facilitate deep thinking through

elaboration. Use strategies which encourage students to observe and modify their own thinking processes. 5- Make thinking processes explicit. Model the metacognitive processes.

### Examples of Schools Teaching Critical Thinking Skills

White (1996) describes the joint Medical Scholars Program between the University of Delaware and the Thomas Jefferson Medical College guided by faculty from the University of New Mexico School of Medicine. This program introduced a few problem-based courses into the undergraduate curriculum for selected premedical students. With the help of additional grants, the idea of problem-based courses is rapidly spreading. White (1996) states that this model for problem-based learning comes from medical schools who have long questioned how well traditional preclinical science courses could train physicians to become problem-solvers and life-long learners. He discusses how information packed lectures to enormous student bodies seemed so far removed from the actual practice of medicine which required integration of knowledge, decision making, working with others and communicating with patients. The effectiveness of the problem-based learning approach in medical school has been supported by a limited number of studies. According to White (1996) the University of Delaware has introduced problem-based learning in a number of undergraduate courses. This was not exclusive to the sciences. The basic principles were applied to international relations as well as art history.

The proposals of the Secretary's Commission on Achieving Necessary Skills and their application to vocational and academic education make the message clear- critical

thinking skills are essential and must be taught (Kerka, 1992). Kerka (1992) describes strategies and applications in the vocational setting. She describes the desirable qualities of the future work force and they include the ability to use critical thinking skills. Critical thinking skills are necessary in the future work force because: 1- occupations are becoming more reliant on cognitive capacities; 2- the changing work environment requires flexibility and adaptability to changing conditions and 3- vocational education provides a real-world context for cognitive development.

Frequently students in the United States are compared to Japanese students with negative results. In the article, “Beyond Fourth Grade Science; Why Do US Students and Japanese Students Diverge?”, Linn, Tsuchida, and Lewis (2000) describe the findings of one small study designed to investigate this issue. The article describes Japanese education in science, points out differences between seen with US science education, and explores implications in the US efforts to improve science education. The article identifies the following eight science activity structures used in Japanese schools. These structures were 1- connect lessons to student interest and prior knowledge; 2- elicit student opinion; 3- plan investigation; 4- conduct investigation; 5- exchange information; 6- analyze and organize data; 7- reflect and revise hypothesis and 8- connect to the next lesson. The underlying current in this classroom structure is the student use of critical thinking skills. Many critical thinking skills are used through the described structure of a typical science activity.

The reputation of Japanese schools is very good and very academically challenging. It is often assumed that this translates into strict, authoritarian teachers focusing purely on academics and increasing students’ acquisition of facts. But this is not the case. Many of

the practices and theories used in the Japanese schools have been influenced by John Dewey, Jerome Brunner, discovery learning, inquiry-based learning, and other Sputnik-inspired reform movements in the US (Linn, Tsuchida, & Lewis, 2000).

### Conclusion

Many of the ideas that have influenced the Japanese system are parts of educational theories and philosophies now tossed around during reform discussions. All of these theories and philosophies have a very large component built on the development of critical thinking skills. Many of these ideas have been around in the United States for many years. The problem has been wide-spread acceptance and implementation of these theories. The U.S. educational systems seem to lack the commitment to see the introduction and implementation of one of these educational movements through to completion. No one seems courageous enough to trash the old system and try again. The focus on critical thinking skills and inquiry learning has the potential to create the desired results in American education if this change in focus was made in the educational system as a whole. Individual teachers can put some or many of these practices into their classrooms. Unfortunately, the tendency of the majority of individuals is to stay with whatever is familiar, so without change coming from higher up, no real reform to embrace the instruction and development of critical thinking skills will take place.

## CHAPTER 3

### Design of the Study

#### Introduction

The New Jersey Department of Education has outlined in the New Jersey Core Curriculum Content Standards a body of knowledge students must have acquired upon completion of their high school careers (New Jersey Department of Education, 1996). The educational leaders in the State Department of Education and beyond seem to have recognized in addition to mastering essential information, to be successful, students must also master certain thinking skills. The New Jersey Core Curriculum Content Standards also identified thinking skills students should have mastered when they exit high school. The standards refer to these skills as “the habits of mind” (New Jersey Department of Education, 1996). These skills are also referred to as problem-solving skills, higher order thinking skills, or simply thinking skills by many. Regardless of what they are called, it is obvious that in order for students to be successful in the fast-paced, ever-changing information age of today and to adjust to what no one is able to anticipate in the future, students must master thinking skills that allow them to learn from their environments and adapt to the new experiences they encounter. It is also obvious that in the classroom things must change. Student performance in the classroom and their test scores indicate that many of the students today have difficulty using critical thinking skills in various contexts.

The purpose of this study was to determine if teaching the use of critical thinking skills primarily through the infusion method improved students' ability to use these critical thinking skills in problem solving situations using a case study method. The results of this study only bear relevance to the science department in Cinnaminson High School and the students enrolled in C.P. Earth Science during the 2003-2004 school year.

#### General Description of the Research Design

One hundred and eight of the one hundred and seventy freshman students who are taking college prep level Earth Science at Cinnaminson High School participated in this study. They were introduced to the concept of critical thinking, the design of the study, and the importance of the study and of critical thinking skills. Students were shown a very general rubric developed by Facione and Facione (1994) of the California Academic Press for scoring activities requiring critical thinking skills.

Over the next five months, students completed six activities (see Appendix A for the six activities) in which students were evaluated on their use of critical thinking skills to solve a series of problems. The activities were divided into two groups of three different types of activities. Each of the first three activities drew upon a different type of background knowledge and asked the students to use different types of critical thinking skills. The second set of three activities was designed to mirror the first three activities in the type of background information and the critical thinking skills required. Activity One was based on the same concept and required the same thinking skills as Activity Four. Activity Two was based on the same concept and required the same thinking skills as Activity Five. Activity Three was based on the same concept and required the same thinking skills as Activity Six.

Activity One and Activity Four asked students to analyze fossil bones and artifacts. The students then predicted the structure of the original organism. Students were also asked to hypothesize details concerning the organism's mode of locomotion, habitat, diet, and interspecies and intraspecies interactions. Every detail of the structure, mode of locomotion, habitat, diet, and interspecies and intraspecies interactions had to be supported by evidence students obtained through analysis of the fossil records.

Activity Two and Activity Five place the student in a different environment than they are accustomed and asked them to describe how they would survive. In Activity Two, the students were required to explain how they would survive using only the items found naturally in an environment if they were deserted with only the clothes they were wearing. The students had to draw on their prior knowledge of that environment and develop a plan that included how they would obtain and prepare food, find or build shelter, withstand the elements, and defend themselves from predators. Activity Five mirrored this activity except the location was now somewhere they chose in space. They had to develop a plan to build an efficient, environmentally friendly, and economically sound colony on some extraterrestrial body. They had to determine what would be needed and then develop a plan to transport the material to the colony in a limited number of trips. The students had to explain how the colony would obtain food, maintain an economy, remain environmentally friendly, and deal with population growth.

Activity Three and Activity Six asked the students to assume the role of the governing body for a planet they helped colonize. The students were asked to develop solutions to two different environmental challenges, energy/fuel shortages and pollution issues. A situation was presented to the students to describe the current conditions and they were



asked to develop a plan to improve the situation. Students had to create both short-term and long-term goals for the colony in overcoming the current situation. The students also had to describe how they would develop their plan, enforce their plan, monitor their plan, and ultimately evaluate the effectiveness of their plan on solving the original problem. Students also had to predict what problems might arise from their plan and explain how they planned on correcting these problems or avoiding these problems. During the course of the study, the teachers involved taught without applying any other intervention to improve the application of critical thinking skills outside the confines of the existing curriculum. The day the activity was completed, the teachers involved introduced or reviewed the critical thinking skills used in the activity and modeled their use through various examples.

A scoring rubric was developed based on the general scoring rubric the students were first introduced to for each activity (see Appendix B for the rubrics). The scores ranged from a zero to a four. The scores of each student for the individual activities were organized in a Microsoft Excel spreadsheet (see Appendix C for complete listing of data). A statistical analysis computer program was used to determine the mean value for each of the six activities for all the students. The scores of Activity One and Activity Four were compared, as were the scores from Activity 2 and Activity 5, and Activity 3 and Activity 6. Graphical Analysis of the mean scores of the activities was also used to show any patterns in the data.

### Development and Design of the Research Instruments

Critical thinking activities are typically open-ended activities that allow students to use sequential cognitive processes to transform information in a strategic manner. Often

activities involving critical thinking skills do not have a single correct response, instead there may be a range of acceptable answers with the focus on the thought processes used by the students to reach their answer.

Three topics were chosen for the development of the activities in this study. The topics were all science related but not specific to one discipline. In seventh and eighth grade in the Cinnaminson School District, the science courses are integrated courses. The activities were based on very general scientific background information to ensure the students would have some prior knowledge from which to draw in analyzing each task. Once a topic was chosen for Activity One, a grade appropriate activity was developed which encouraged student use of critical thinking skills in applying prior science knowledge they have mastered to a unique task. After the activity was developed, a rubric was created which scored students based on the critical thinking involved in each response. Once Activity One was developed a similar activity was created, Activity Four, which mirrored the concept of Activity One and the critical thinking skills involved. In a similar manner Activity Two and Activity Five, and Activity Three and Activity Six were developed.

#### Description of Sampling and Sampling Technique

One hundred and thirty of the one hundred and seventy students in the freshman class were chosen for this study. All of these students were taking college prep level earth science with one of two teachers involved in the study. Freshman were selected for this study to determine what effect additional activities focusing directly on critical thinking skills had on students' use of critical thinking skills in science courses. Students taking earth science at the college prep level were chosen to eliminate other variables within the

student population that may affect the data collected such as ability level or exposure to different courses. The two teachers were chosen for this study because they shared a similar teaching style and worked closely to coordinate their lessons. This reduced teaching style as a variable that may have affected the data of the study.

#### Description of the Data Collection Approach

The data that was collected in this study consisted of scores from a Holistic Critical Thinking Scoring Rubric. The scores ranged from zero to four. A rubric was designed specifically for each activity to score student performance on particular critical thinking skills. Scores were collected for each student for all six activities. The classroom teachers were responsible for scoring the papers for their own classes. The intern inserviced the other teacher participating in the study on how the rubrics were constructed and how the rubrics were used to score the papers. A portfolio was kept consisting of each students' work by the teacher of student. The scores were reported to the intern at the completion of the study. The scores were recorded in an Excel spreadsheet.

#### Description of the Data Analysis Plan

The data collected, the rubric scores for the six activities for each student, were statistically analyzed to determine if there was a statistically significant difference between the mean rubric scores of Activity One and Activity Four, Activity Two and Activity Five, and Activity Three and Activity Six. The statistical analysis program Microsoft-SSPS was used for the data analysis.

The mean of the rubric scores for Activity One was compared to the mean of the rubric scores for Activity Four. It was then determined if there was a difference in the

mean scores and if that difference was statistically significant. These two activities were designed to analyze similar critical thinking skills. The mean of the rubric scores from Activity Two and Activity Five were compared to find a difference and the difference was analyzed for a statistical significance. Both of these activities were designed to analyze similar critical thinking skills. The mean of the rubric scores for Activity Three and Activity Six were analyzed to determine if a difference existed and if that difference was statistically significant. The results of the statistical analysis of the three pairs of activities were then analyzed to determine if a pattern of improvement existed. The pattern was examined by graphing the differences in the scores for the six activities.

## CHAPTER 4

### Presentation of Research Findings

#### Introduction

The purpose of this study was to evaluate the effectiveness of the pedagogical practice of teaching the use of critical thinking skills through the infusion method currently used by the science department in Cinnaminson High School. This study specifically examined freshman to assess the direct impact of the teaching method rather than assessing the accumulating effects of other classes and teachers on older students. Over the course of six months, while being taught the traditional curriculum used in Cinnaminson High School, students' application of critical thinking skills was evaluated by the completion of six activities requiring the use of critical thinking skills. The six activities were divided into two groups. The first three activities were designed based on particular scientific topics requiring students to use specific critical thinking skills to complete the activity. The second series of three activities feature activities that mirrored the first three activities in the scientific topic, the critical thinking skills required and the level of difficulty. A rubric was developed separately for each activity based on the rubric developed by Facione and Facione (1994). Data was collected in the form of rubric scores ranging from 0 to 4. This data was analyzed statistically using the Windows-SSPS program.

In determining if the infusion method currently used to teach the application of critical thinking skills to freshman taking college prep level Earth Science lead to a statistically

significant improvement in students' scores on activities that involve the use of critical thinking skills, several sub-questions had to first be addressed.

Do Students in the Cinnaminson School District Have Difficulty Applying Critical Thinking Skills in Problem-Solving Situations?

First it was necessary to establish the fact that students in the Cinnaminson School District have difficulty applying critical thinking skills in problem-solving situations. This was accomplished primarily through teacher interviews. In the beginning of the school year, the teachers of the science department in the middle school and the high school were interviewed. During the interview teachers were read the definition of critical thinking skills and then asked the questions below:

CRITICAL THINKING SURVEY  
FOR SCIENCE TEACHERS  
IN THE CINNAMINSON SCHOOL DISTRICT

Critical thinking skills: Evaluating conclusions by logically and systematically examining the problem, the evidence, and the solution.

- 1) Do students have difficulty:
  - a) reading the question and understanding what is being asked?
  - b) identifying central issues or problems?
  - c) comparing similarities and differences?
  - d) determining what information is relevant?
  - e) formulating appropriate questions?
  - f) applying scientific knowledge to the problem?
  - g) interpreting data?

- h) drawing conclusions from the results of an experiment?
- 2) Please provide examples of three activities in your classroom which require students to use critical thinking skills.
- 1)
  - 2)
  - 3)
- 3) Have you recognized other problems students have in applying critical thinking skills in the activities in your classroom?

In these interviews, all the teachers agreed that the students did in fact struggle a great deal with activities or problems requiring critical thinking. This was consistent with teachers of students who were in grades 7 through 12. The critical thinking skills that teachers identified as the ones students had the most difficulty using varied. Most mentioned, however, that students had difficulty applying knowledge or skills they had previously learned in a new context. The science department chairman, when interviewed, also stated that deficiencies in the use of critical thinking skills were apparent in the Terra-Nova results of the current ninth grade. Through these interviews it also became apparent that there was, in fact, no strategies or programs used that directly taught critical thinking skills.

Which Critical Thinking Skills Do Students in Cinnaminson High School Have the Most Difficulty Applying in Problem-Solving Situations?

The teachers, when interviewed, did not uniformly agree on a list of critical thinking skills students had difficulty applying in problem-solving situations. Although, a general theme did develop in their responses of students having difficulty analyzing data and

situations, interpreting data or observations, and drawing conclusions based on data or observations. The one common response among all of the teachers was students' inability to apply previously acquired scientific knowledge to new situations.

### How Can the Improvement in the Application of Critical Thinking Skills By Students Be Measured?

The Grade Eight Proficiency Assessment and the High School Proficiency Assessment both are designed to ultimately test students' use of critical thinking skills in solving scientific problems. Activities modeled after the types of questions on these tests can be used in the classroom to evaluate students' use of critical thinking skills. Rubrics designed specifically for the individual activity provide the best feedback. However, a generic rubric evaluating critical thinking skills use can be used to provide some useful feedback.

### How Effective is the Infusion Method for Teaching the Application of Critical Thinking Skills?

The completion of this study revealed some very interesting and potential useful information. The teachers involved in this study reported that students were very perplexed at the beginning of activities one through three. They expressed difficulty in discerning what type of response they were being asked to provide and they worried about the "correct answer" despite being reassured that responses were to be individualized and there was not one "correct answer." The teachers involved in the study had to provide examples of the type of critical thinking skills students should be using to provide a complete answer to the problem. Students' use of critical thinking skills in their responses also varied depending on their interest in the topic of the activity. It was obvious that applying critical thinking skills was difficult and



some students on some of the activities decided not to put forth the effort.

Analysis of the data provided a great deal of information. The most obvious characteristic of the data was that the students' scores were very inconsistent. This inconsistency was evident in the mean scores of the activities. The mean scores for Activity One through Activity Six were as follows, respectively: 2.49, 2.55, 2.25, 2.67, 2.20, and 2.07. Also evident in the mean scores was that the students' scores were low. When statistical analysis of the data was completed the pattern of inconsistency continued. The analysis of the data revealed the following results:

Activity One	Activity Four	Significance
2.49	2.67	$p(107) = .115$
Activity Two	Activity Five	Significance
2.55	2.20	$p(107) = .001$
Activity Three	Activity Six	Significance
2.25	2.07	$p(107) = .076$

The only pair in which there was a statistically significant change was in Activity Two and Activity Five. The change, however, was not positive. There was a statistically significant decrease in the mean score from 2.55 to 2.20.

## Conclusion

This study found that students presently enrolled in the Cinnaminson School District have difficulty applying critical thinking skills in problem-solving situations. According to teacher interviews, students in grades 7 through 12 all exhibited the problem. This study focused on a sample of freshman students taking college prep level earth science this year. Teachers did not necessarily agree upon a list of specific critical thinking skills students struggled with the most, but they all seemed to agree that students had difficulty processing information through interpreting and analyzing data, drawing conclusions based on data, and applying knowledge gained previously in a new context. The science chairman reported that the Terra-Nova and GEPA test results supports the teachers claims.

This study further demonstrated that the students participating in the study had difficulty applying critical thinking skills in problem-solving situations. The mean scores of the activities all fell within a range from 2.07 to 2.67 on a scale of 0 to 4. The data also indicated that there was no statistically significant increase in scores as the year progressed as a result of using the infusion method to teach critical thinking skills. In only one pair of activities was there an increase in the mean scores, this increase was in the paired activities One and Four.

## CHAPTER 5

### Conclusions, Implications, and Further Study

#### Introduction

The data and information collected in this study revealed a great deal about the abilities of students in the Cinnaminson School District to use critical thinking skills in problem-solving situations. With information and technology changing so rapidly in today's society and the changing demands being placed on the students of today, the educational system must be sure that it is meeting the needs of the students by preparing them to be successful in the future. With society changing so quickly, what is important for students, now more than ever, is the ability to draw on the knowledge they have acquired and apply it in new contexts when solving problems. Schools can no longer hope to expose students to all or almost all of the situations or demands that they will encounter as adults. Most of these situations are not present now and some are not even imaginable with the current technology available. With advances and discoveries occurring at the rapid rate which they are, the problems and issues now unimaginable will be the students' reality in the future. Schools must prepare students by equipping them with the skills necessary to navigate this foreign terrain.

#### Conclusions and Implications

The information collected in this study provided evidence of areas the science department in the Cinnaminson School District could make improvements to better

prepare their students for the future that awaits them. The anecdotal information provided by the teachers and the information the science chairman stated the Terra-Nova and the GEPA results revealed were supported by the findings in this study. Students in the Cinnaminson School District have difficulty applying critical thinking skills in problem-solving situations.

The data collected may not provide a completely accurate picture of the students' ability who participated in the study. Many students' found that the activity required a great deal of thought so they did not apply themselves fully to each task allowing their true abilities to be evaluated. Another problem that was evident in this study was that students found the second set of activities repetitious. In order to gain an accurate record of their progress in improving critical thinking skills, the second set of activities was designed to mirror the first in topic and skills required. A comment frequently expressed by the students when given the activities of the second set was that they had already completed this activity. Although they were somewhat different, they were similar enough the students felt the topic no longer interested them and they had already put effort into completing this task and could not get excited about doing it again. This lack of interest the second time around was clearly evident in the pairings of Activity Two and Activity Five and Activity 3 and Activity 6. The pairing that did exhibit an increase in the mean scores was Activity One and Activity 4. Activity One was the first activity of the study and the students were unsure of what was expected of them and really had difficulty comprehending the idea that there really was not one "correct response" so they really held back expressing their thoughts trying to figure out the desired response. By Activity Four, students had really developed an idea of what the activities were asking

them to do. Because they finally understood, they expressed excitement in their understanding and were really motivated to complete this activity.

### Implications of Study on Leadership Skills

This study fostered the growth of the intern in several ways. As stated in ISLLC Standard 1: A school administrator is an educational leader who promotes the success of all students by facilitating the development, articulation, implementation, and stewardship of a vision of learning that is shared and supported by the school community. Conducting this study furthered the development of the intern's knowledge and understanding of the principles of developing and implementing strategic plans; information sources, data collections, and data analysis strategies; and effective communication. This study was strengthened the intern's belief and commitment to: ensuring that students have the knowledge, skills, and values to become successful adults; a willingness to continuously examine one's own assumptions, beliefs, and practices; and doing the work required for high levels of personal and organizational performance. The intern, during the course of this study, improved her ability to facilitate, process, and engage in activities that ensure that: the school community is involved in improvement efforts; an implementation plan is developed in which objectives and strategies to achieve the vision and goals are clearly articulated; assessment of data related to student learning are used to develop the school vision and goals; and the vision, mission, and implementation plans are regularly monitored, evaluated, and revised.

ISLLC Standard 2 states that a school administrator is an educational leader who promotes the success of all students by advocating, nurturing, and maintaining a school

culture and instructional program conducive to student learning and staff development. This study contributed to the growth of the intern in relationship to this standard by strengthening the intern's knowledge and understanding of: student growth and development; applied learning theories; curriculum design, implementation, evaluation, and refinement; measurement, evaluation, and assessment strategies; and the change process for systems, organizations, and individuals. This study reinforced the intern's beliefs and commitment to: student learning as the fundamental purpose of schooling; the proposition that all students can learn; professional development as an integral part of school improvement; and preparing students to be contributing members of society. By completing this study the intern's ability to facilitate, process, and engage in activities that ensure: multiple opportunities to learn are available to all students; curriculum decisions are based on research, expertise of teachers, and the recommendations of learned societies; a variety of sources of information is used to make decisions; and student learning is assessed using a variety of techniques.

#### Implications of Study on Organizational Change

From this study it can be seen that the students in the Cinnaminson School District need to improve their abilities in applying critical thinking skills in problem-solving situations. The students can not accomplish this alone. The science department must help the students by adjusting the courses to meet the needs of the students. This could be accomplished in many different ways. The department could continue to use the infusion method to teach critical thinking skills but put a greater emphasis on activities and evaluation methods which require the students to apply critical thinking skills rather than simply recalling information through rote learning.

Since the application of critical thinking skills is a tool students need to possess not only in science but also in their other courses of study, it might be appropriate to discuss the difficulties seen in the science department with other department chairman. If it is determined that the problem also is apparent in other departments, maybe a critical thinking skills program should be investigated that can be used throughout the whole school or district.

Also evident in this study was teachers' lack of understanding of the importance of completing critical thinking skills activities. At times, particularly in science, there is such a great emphasis on "covering the curriculum" that these activities might seem to be a hindrance to the teacher. It must be made clear that an accumulation of all the facts in the world will do no good for these students if they are unable to process and use the information when the situation requires. Teachers should also be made familiar with the concept of grading based on a rubric and not looking for that one correct answer, but rather examine the thought process in each response.

### Further Study

The results of this study indicate areas for improvement in the Cinnaminson Public School District's science department. Critical thinking skills are skills all educators need to be concerned about developing in students. Future studies that could contribute to the growth of the department and the success of the students should be considered. After discussion with the department of the data and findings of this study, a decision should be made concerning the approach that should be used to improve critical thinking skills. If the infusion method is to be kept as the primary method of teaching critical thinking

skills, then ways to refine and reinforce instruction of these skills needs to be discussed. Starting in September, this intervention needs to be in place and a study similar to this one should be conducted to see if there is an improvement.

If the department would like to try a new approach to teaching critical thinking skills, the programs that are available need to be reviewed. The programs that best fit the needs of the district should be selected. Starting in September, the selected programs should be used with a sample population of students. Again a study similar to this one can be used to monitor the progress of the students.

An evaluation of the use of critical thinking skills through all subjects would also be a worthwhile, but quite extensive, study. Based upon the results of this study the determination of the need for a district-wide critical thinking skills program that is separate from all subjects can be made.

In the rapidly-changing society of today, that has shown no signs of slowing down, the need for people to be able to apply critical thinking skills to be successful is obvious. The uncertainty of the future makes it impossible to prepare students for all the situations they will likely encounter and provide them with the majority of the knowledge and skills they will need. With society changing, so must the educational system. The educational system must now equip students with the ability to process, analyze and interpret new information as it develops to be successful.



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Appendix A  
CRITICAL THINKING ACTIVITIES ONE THROUGH SIX

*ACTIVITY #1*  
**BONEDIGGERS**

You are a student of paleontology at Drexel University. Paleontology is the science dealing with the life of past geological time periods as known from fossils. You have been invited to an excavation site in Utah where paleontologists believe they have discovered a new species. They have found various parts of the skeleton and would like your help in reconstructing the most probable structure of the animal. They would like you to study the skeleton and describe what you believe the structure of the animal would have looked like. They would also like you to hypothesize on the following, its:

- habitat
- diet
- mode of locomotion
- interactions with members of its own species
- interactions with other species

Be sure to include in your description details of the structure and provide evidence from the fossils to support each detail.

## ACTIVITY #2

### SURVIVOR: Can You Live Off The Land?

Congratulations!!! You have been chosen to be the next contestant on the new reality television show “Survivor: With Just The Shirt On Your Back!!!” Your challenge, should you accept, is to live off the land for two weeks. The conditions of this challenge are that you can not bring anything with you except for the items of clothing you choose to wear the day you leave on your excursion. You must choose where you want to be dropped off from the list of places that follows: the steepest slope of the Himalayan Mountains, a deserted island off the coast of South America, a rainforest in Brazil, or the savannahs of Africa. In the space provided below explain what items of clothing you would select to take with you and why you would take them, explain what you would do for shelter, describe what you would eat and drink and how you would obtain and cook it, and finally describe how you would defend off the worst predators of the region and survive with worst weather conditions possible in the areas (because of course you will be subjected to both). GOOD LUCK!!!!

ACTIVITY #3  
CHALLENGE:  
ATLANTICA

You are a member of the Energy Team of the Continent-State of Atlantica. Your homeland, like the rest of the planet Tryon IV, is worried about its energy supply. Some experts predict drastic cutbacks in industrial production if corrective actions are not taken soon. The *challenge* is to figure out how to keep the factories of Atlantica operating and society continuing without bankrupting the economy, polluting the environment, or severely dislocating the prosperous and peaceful society that your people have built.

Members of your Team have brought the following facts to your committee meeting. Use their information and your own personal knowledge and strategic planning to develop a plan to supply Atlantica with the energy needed to operate without bankrupting the Continent-State, polluting the environment, or creating changes in the food web that naturally exists on the planet.

- The Secretary of Health says that “rush hour Smog” in the capital city of Greater Rory has reached a level dangerous to the ill and the elderly.
- Grains are very plentiful on the planet. The current practice is to use the grains to fatten up the primary food source: beefalo.
- Preliminary surveys indicate sizeable deposits of oil and coal in the remote subcontinent of South Atlantica.
- The Continental Controller of Applied Research proposes investing a large sum of money to develop a new antimatter engine which will harness energy released when electrons and positrons collide.
- The Superintendent of the Interior has proposed a permanent solution; harnessing energy from biomass farms. He has left the details for you to figure out.
- The Secretary of the Environment reports unusually warm winters during the last five years that have begun to melt glaciers near the North Pole. Inhabitants of Westlandia’s coastal region are worried that the Atlantica Ocean levels will rise causing major flooding.

Good luck in creating an energy supply plan that will allow Atlantica to prosper. Be as creative as possible.



#### *ACTIVITY #4*

##### Another Branch of the Evolutionary Tree?

You are an expert anthropologist who is among the many scientists trying to disprove the “out of Africa” theory. You recently received a phone call from a group studying an excavation site in southern India. The group asked if you could come out to see what they are calling the discovery of another branch of the evolutionary tree of hominids. They would like your opinion before they report their findings in the next issue of a reputable journal of anthropology. You asked them if they could fax you a copy of a picture of the fossils they have discovered so you can do some preliminary work before you arrive. On the long plane ride you have decided to try to “reconstruct” the body the bones may have belonged to as well as develop a description of the existence of the early hominid. Below is a copy of the fax. Write a detailed description of the physical structure of the hominid. Include in your description your ideas on height, weight, body alignment, hair (amount, texture, color and function), skin color, diet, lifestyle (i.e. hunter, farmer, gatherer) and a hypothesis concerning interactions with other animals and other hominids. You must provide evidence to support all of your hypotheses.

*ACTIVITY #5*  
THE COLONIZATION OF MARS

The conditions on earth are deteriorating rapidly. The pollution is destroying the atmosphere. The development of area land is removing the majority of the plants that could possibly reverse the conditions of the atmosphere. The greenhouse gases are accumulating in the atmosphere at an accelerated pace. Extinction of species is rampant. The leaders of the world have decided that planet earth is beyond repair. They have decided to invest the money reserves into colonizing Mars.

You have been selected to be a member of the committee in charge of the colonization of Mars. Funds are limited in the beginning until you prove you are going to be able to create a sustainable colony on Mars. The leaders of the world have asked you for a summary of the plan you have developed for the colonization of Mars. In your plan you must explain: what steps you intend to take to overcome the lack of an atmosphere on Mars; how you plan on creating a renewable food supply on Mars (and what you intend on using for food in the meantime); designs for shelter and transportation on the Red Planet; and finally what people will do you recreation once on Mars.

ACTIVITY #6  
CHALLENGE: HOMECA

You are a member of the Energy team of the Continent State of Homeca. Your homeland, like the rest of the planet Tyron IV, is feeling the pressure of a rapidly growing population. Some experts predict severe food shortages if corrective steps are not taken soon. The challenge is to figure out how to feed all your people without severely dislocating the prosperous and peaceful society that your people have built. A few key points brought to your attention by the President when he presented your team with this task are listed below. You do not need to agree with the points listed below but you must address them in your plan. Your report is expected soon. The entire planet is counting on you. Good luck.

- The Educator- General of Homeca School Board advocates strict population control.
- Spokeswoman for the fisheries board says that to increase the food supply the pollution in the lakes, streams, and wetlands must be decreased (how?).
- Some members of your team have suggested you identify factors that determine population size and the figure out which are controllable.
- Representatives from the agriculture, technical, industrial, and government communities want their positions considered in developing the plan.

**Appendix B:**  
**RUBRICS FOR THE SCORING OF**  
**CRITICAL THINKING ACTIVITIES ONE THROUGH SIX**

**RUBRIC FOR SCORING**  
**ACTIVITY #1**

**BONEDIGGERS**

4- Described in detail the structure of the animal with supporting facts from the fossil records (at least 4 supporting facts). Provided a detailed description of the likely habitat of the animal and supported it with structural evidence from the fossil. State the type of diet the animal probably fed on and support with evidence from teeth, claws or nails, size and likely habitat. Hypothesized about the interactions of the animal with its own species and other species and provided at least 3 supporting facts from the fossil records.

3- Described the structure of the animal with supporting facts from the fossil records (at least 2 supporting facts). Provided a description of the likely habitat of the animal but did not provide supporting evidence or the evidence provided did not support hypothesis concerning habitat. Stated the type of diet the animal probably fed on and provided evidence from one of the following sources: teeth, claws or nails, size or likely habitat. Hypothesized about the interactions of the animal with its own species and other species but did not provide supporting facts from the fossil records.

2- Described the structure of the animal with supporting facts from the fossil records (only 1 fact). Description may have contradicted other structures. Identified a habitat the animal most likely inhabited but did not provide supporting facts. Stated the type of diet the animal probably fed on but did not provide evidence supporting this hypothesis. Hypothesized about either the interactions of the animal with its own species or other species but did not provide supporting facts from the fossil records.

1- Described the structure of the animal in limited detail. Provided at least one supporting fact from fossil evidence but the evidence may have been contradictory. Identified a habitat but did not provide supporting facts. Failed to identify the diet the animal probably fed on. Hypothesized about either the interactions of the animal with its own species or other species but did not provide supporting facts from the fossil records and contradicted the evidence provided by the fossils.

RUBRIC FOR SCORING  
*ACTIVITY #2*  
SURVIVOR: Can You Live Off The Land?

4- Described in detail the items of clothing chosen to wear. Provided reasoning for at least four items of clothing. Explained what shelter would be used in the environment selected. The shelter was reasonable and provided dry, safe protection from predators and severe weather conditions. Provided details about what would be eaten and drank and how it would be obtained. Explanations were reasonable. Explained how they would handle severe weather conditions and predators. The conditions explained must describe a situation in which a person could thrive.

3- Described in detail some of the clothing chosen to wear. Provided reasoning for at least two items of clothing. Explained what shelter would be used in the environment selected. The shelter was reasonable but some what risky when facing predators and severe weather conditions. Provided details about what would be eaten and drank and how it would be obtained. Some explanations were not reasonable. Explained how they would handle severe weather conditions or predators. The conditions explained must describe a situation in which a person could survive.

2- Described some of the clothing chosen to wear. Provided reasoning for one item of clothing. Stated what shelter would be used in the environment selected. The shelter was not safe or permanent and provided little protection from predators or severe weather conditions. Provided a list of a limited diet and how it would be obtained. Did not explain how severe weather conditions and predators would be handled. The conditions explained must describe a situation in which a person's survival is questionable.

1- Listed the some of the items of clothing chosen to wear. Provided no reasoning for the items of clothing chosen. Stated the shelter that would not be sufficient in the environment selected. The shelter described failed to provide protection from predators and severe weather conditions. Listed items to be eaten or drank and how it would be obtained. Some of the items were not reasonable. Did not explain how severe weather conditions and predators would be handled. The conditions explained must describe a situation in which a person could not realistically survive.

## RUBRIC FOR SCORING

### ACTIVITY #3

### CHALLENGE:

### ATLANTICA

4- Provided a plan to supply Atlantica with the energy needed for the Continent-State Atlantica. Two reasonable suggestions to combat rush hour smog were described. A plan for the grains was described, even if the plan suggests continuing the current use of the grains. The deposits of oil and coal are addressed with a reasonable plan for their use or an alternative energy supply was described. Position on investing large sums of money into the development of a new antimatter engine was described. Biomass farms were addressed. Suggestions, at least three, were given for how to slow the trend of warming temperatures.

3- Provided a plan to supply Atlantica with the energy needed for the Continent-State Atlantica. A suggestion to combat rush hour smog was described. The suggestion to continue the use of the grains as described was given. Use of deposits of oil and coal was addressed and similar to the use on earth. A plan to extract and transport the reserves was outlined in minimal detail. Biomass farms were addressed. Suggestions, only two, were given for how to slow the trend of warming temperatures, some may not be practical.

2- Provided a plan to supply Atlantica with some of the energy needed for the Continent-State Atlantica. A suggestion to combat rush hour smog was described. The suggestion to continue the use of the grains as described was given. Use of the deposits of oil and coal was addressed and similar to the use on earth. A suggestion for how to slow the trend of warming temperatures was given.

1- Provided an outline of a plan to supply Atlantica with some of the energy needed for the Continent-State Atlantica. The plan was similar to what is in place on earth. The suggestion to continue the use of the grains as described was given. A suggestion for how to slow warming temperatures was given but may not have been reasonable.

## RUBRIC FOR SCORING

### ACTIVITY #4

#### Another Branch of the Evolutionary Tree?

4- Described in detail the physical structure of the hominid. Included in the description were details of the probable height, weight, body alignment, hair (amount, texture, color and function), skin color, and diet. Each of the hypotheses concerning these characteristics was supported by evidence from the fossil record and the location of the site of the excavation. Explained in detail the likely diet and lifestyle based on the stage in evolution estimated, structural components, and analysis of the tools found near the body.

3- Described the physical structure of the hominid. Included in the description were details of some (but not all) of the following: probable height; weight; body alignment; hair; skin color; and diet. Some of the hypotheses were supported by evidence from the fossil record but some of the evidence provided may have been contradictory. Described the probable diet and identified the stage of evolution of the hominid. These hypotheses were based on one or two of the following facts: the stage in evolution estimated; structural components; and analysis of the tools found near the body.

2- Described the physical structure of the hominid. Included in the description were statements concerning some (but not all) of the following: probable height; weight; body alignment; hair; skin color; and diet. Some of the hypotheses were supported by evidence from the fossil record but some of the evidence provided may have been contradictory. Hypothesized the probable diet but failed to recognize the importance of the stage of evolution of the hominid. Recognized significance of the tools but failed to identify what characteristics they support.

1- Described the physical structure of the hominid. The description was not supported with evidence from the fossil records. Some of the features described were contradictory to the evidence provided by the fossil records. Stated a probable diet but did not provide supporting evidence or with contradictory evidence. Failed to include the contribution of the tools to determining the physical structure of the hominid.

Write a detailed description of the physical structure of the hominid. Include in your description your ideas on height, weight, body alignment, hair (amount, texture, color and function), skin color, diet, lifestyle (i.e. hunter, farmer, gatherer) and a hypothesis concerning interactions with other animals and other hominids. You must provide evidence to support all of your hypotheses.



RUBRIC FOR SCORING  
*ACTIVITY #5*  
THE COLONIZATION OF MARS

4- Described a plan that explained in detail the steps taken to overcome the lack of an atmosphere. The plan must be reasonable and cost efficient. A plan to create a renewable food supply was described with a plan to provide food while the continual food supply is developing. Designs for shelter and transportation were detailed. A plan to get the materials to build the structures, the manpower needed to build the structures and a transportation system that is cost efficient and environmentally friendly was described. A plan for recreation was described with alternative activities provided.

3- Described a plan that explained the steps to overcome the lack of an atmosphere. The plan was reasonable, but may have been difficult to accomplish. A plan to create a renewable food supply was described but a plan to provide food while the continual food supply is developing was not provided. Designs for shelter and transportation were described without details. A brief description of how to get the materials to build the structures, the manpower needed to build the structures and a transportation system was described. The plan was similar to what is presently in place on earth. The plan included some features that were cost efficient and environmentally friendly. A few activities were listed for recreation on the Red Planet.

2- Listed steps to overcome the lack of an atmosphere, some of the steps may not have been reasonable. A plan to provide food to the growing colony on Mars was described but the plan did not include a renewable food supply. It was a very costly plan with many areas where breakdowns are possible. Designs for shelter and transportation were similar to what is presently on earth without any improvements. Several activities were listed for recreation on the Red Planet.

1- Addressed the lack of atmosphere with a plan that was not reasonable, cost efficient or a long-term solution. A plan to provide food to the growing colony on Mars was described but the plan did not include a renewable food supply. It was a very costly plan with many areas where breakdowns are possible. Designs for shelter and transportation were similar to what is presently on earth without any improvements or other suggestions that are not reasonable or possible. One activity for recreation is listed or recreation is not included in the plan.

RUBRIC FOR SCORING  
*ACTIVITY #6*  
CHALLENGE: HOMECA

4- Described a plan to feed the population. The plan described a renewable food supply that took into consideration the health of the planet and the lifestyles of the people in the community. The plan addressed the Educator-General of Homeca School Board's idea to enforce strict population control. The plan addressed the suggestion of increasing the food supply by decreasing pollution in lakes, streams, and wetlands. Methods for decreasing pollution were identified. Factors that determine population size were identified and the ones that are controllable were identified. The positions of the agricultural, technical, industrial, and government communities were considered.

3- Described a plan to feed the population. The plan described a renewable food supply. The plan addressed the Educator-General of Homeca School Board's idea to enforce strict population control. The plan addressed the suggestion of increasing the food supply by decreasing pollution in lakes, streams, and wetlands. The positions of the agricultural, technical, industrial, and government communities were considered.

2- Described a plan to feed the population. The plan described use of a renewable food supply and reliance on a non-renewable food source. The plan addressed the Educator-General of Homeca School Board's idea to enforce strict population control. The plan addressed the suggestion of increasing the food supply by decreasing pollution in lakes, streams, and wetlands. The plan did not describe a food supply that could continue to support a growing population.

1- Described a plan to feed the population. The plan described the reliance on a non-renewable food source to get the population out of crisis. The plan addressed the Educator-General of Homeca School Board's idea to enforce strict population control. This may have been the basis for the plan. The plan did not describe a food supply that could continue to support a growing population.

**Appendix C:**

**RUBRIC SCORES FOR ACTIVITIES ONE THROUGH SIX**

RUBRIC SCORES FOR ACTIVITIES ONE THROUGH SIX

Student #	# 1	# 2	# 3	# 4	# 5	# 6
1	3	3	3	2	2	3
2	4	3	3	2	4	3
3	4	2	2	3	2	1
*4	4	3	3	3	3	
5	4	3	2	3	2	2
6	2	3	3	2	2	2
7	4	3	1	2	2	3
8	4	3	3	1	4	3
10	2	3	2	3	4	3
11	2	3	2	1	2	3
12	4	3	3	4	4	3
13	4	4	2	4	3	2
14	3	2	2	3	3	2
15	3	1	3	1	2	2
16	2	4	3	3	3	3
18	2	2	2	4	2	2
19	4	4	4	4	4	4
20	1	3	4	3	3	3
21	4	4	3	4	4	4
22	3	4	2	3	4	3
23	3	4	3	4	4	4
*24		1	1	1	2	3
25	1	4	1	2	1	2
27	4	3	3	3	1	2
28	3	4	2	3	3	3
29	1	2	2	2	2	2
30	3	2	3	3	1	1
31	2	4	4	4	4	4
32	3	4	3	4	2	3
33	2	2	2	2	2	2
34	2	2	2	3	2	2
35	2	2	3	4	3	3
36	3	3	2	3	3	2
37	4	4	2	4	3	2
38	3	1	2	2	1	1
39	3	1	3	3	1	3
40	2	4	3	3	3	2
*41			3	2	3	2
42	4	3	4	4	4	3
43	2	2	3	4	4	4
44	1	2	2	3	2	3

Student #	# 1	# 2	# 3	# 4	# 5	# 6
45	2	3	2	3	3	1
*46						
*47						
48	2	1	2	3	1	2
49	2	2	3	1	0	0
50	1	2	1	1	1	1
51	1	2	2	1	3	4
52	3	4	3	4	4	4
53	3	1	2	1	1	2
54	3	2	1	2	2	0
55	3	4	3	2	2	3
56	4	3	3	4	4	3
57	3	3	2	3	1	3
58	3	3	2	3	1	3
59	1	1	1	1	2	1
60	1	1	3	1	2	2
61	3	2	2	1	2	2
62	2	2	1	3	3	2
63	3	3	3	3	3	3
64	1	3	2	1	1	1
65	1	2	3	3	2	2
66	3	2	2	2	2	1
67	2	4	2	3	3	3
68	2	2	2	2	1	3
69	3	3	3	4	3	3
70	2	2	2	3	1	3
71	2	0	2	1	1	3
72	3	2	1	2	3	1
73	3	2	2	3	1	1
74	3	3	3	3	1	1
75	1	2	1	2	2	2
76	2	3	2	2	2	2
77	4	2	3	3	2	3
78	2	2	2	3	2	3
79	3	3	2	2	2	2
80	2	3	1	3	1	2
81	3	3	3	3	3	1
82	2	2	1	3	1	1
83	2	3	3	3	3	2
84	4	2	3	2	3	1
85	3	3	2	2	2	1
86	2	3	3	3	1	1
87	3	1	3	3	1	1

Student #	# 1	# 2	# 3	# 4	# 5	# 6
88	2	2	2	2	1	1
89	3	3	3	3	2	2
90	3	2	1	1	1	2
91	1	2	1	1	1	1
92	3	3	2	2	1	1
93	3	2	3	3	1	1
94	2	2	2	1	1	1
95	3	2	1	1	1	1
96	2	2	3	2	2	1
97	2	2	2	4	4	1
*98						
99	1	3	1	3	3	1
100	4	2	3	3	1	3
101	2	3	3	3	2	3
102	2	2	1	3	2	3
*103	3	2		4	3	1
104	3	3	3	3	2	2
105	3	3	2	4	3	1
*106	3	3		4	3	1
107	1	2	1	3	2	0
108	1	2	1	3	2	1
109	3	2	3	4	2	3
110	3	3	4	4	3	2
111	1	2	1	2	4	1
112	2	3	3	3	2	3
113	1	2	2	2	0	0
114	1	3	2	4	0	1
115	2	3	2	2	3	2

\* data not used in analysis because it was incomplete, students did not complete all six activities

## Biographical Data

Name	Kristen May
High School	Highland High School Erial, NJ
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Graduate	Master of Arts Educational Leadership Rowan University Glassboro, NJ
Present Occupation	Science Teacher Cinnaminson High School Cinnaminson, NJ