# AN ANALYSIS OF CRITICAL THINKING SKILLS IN COMPUTER INFORMATION TECHNOLOGY USING THE CALIFORNIA CRITICAL THINKING SKILLS TEST

by


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A Research Paper
Submitted in Partial Fulfillment of the
Requirements for the
Master of Science Degree
in

Career and Technical Education

Approved: 2 Semester Credits

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April, 2006

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Title: *An Analysis of Critical Thinking Skills in Computer Information Technology using the California Critical Thinking Skills Test*

Graduate Degree/ Major: Career and Technical Education

Research Adviser: Dr. Mike Galloy

Month/Year: June, 2006

Number of Pages: 51

Style Manual Used: American Psychological Association, 5th edition

**ABSTRACT**

Colleges and universities across the country are changing their educational standards by providing graduates with more than just the tangible skills they need to be competitive and productive in the workforce, they are also providing students with the opportunity to be better thinkers by providing learning plans that activate and enhance students' higher-order thinking skills. This high-order thinking is often called critical thinking and involves judgment, analysis, and synthesis (Halpern, 1998, ¶ 10).

Many of the educational institutions that are consciously trying to improve students' critical thinking also want to measure the effectiveness of these improvements. This is often done using a causal-comparative study requiring students to take a critical skills test during their first semester (pre-test) and then the same test just before they graduate (post-test). The data from these tests is then used to statistically analyze the effectiveness of educational enhancements meant to teach critical thinking skills.

There are many critical thinking assessment tests available that will effectively measure critical thinking skills. Examples of these critical thinking assessment tests include the Watson-Glaser Critical Thinking Appraisal (WGCTA) test, the Thurstone Test of Mental Alertness, the Cornell Critical Thinking Test, and the California Critical Thinking Skills Test (CCTST).

The purpose of this study is to use the CCTST assessment tool on a computer information technology (CIT) unit of instruction at Northcentral Technical College (NTC) to measure the effectiveness of critical thinking teaching methodologies. The CCTST assessment tool has been administered by NTC since August of the year 2000. The data from this study was analyzed to identify statistical significant differences between pre-test CCTST group mean scores and post-test CCTST group mean scores. Through the use of independent t-tests to compile the data and with a probability level set at .05, this study determined that the group mean scores from the post-test were not significantly higher than the pre-test group mean scores ($p > .05$).

# TABLE OF CONTENTS

# CHAPTER I

## Introduction

Computer information technology (CIT) inarguably is shaping our society and the future. Intel Corporation, for example, a leading producer of microprocessors, has 7000 researchers worldwide who are continually making strides in discovering new, real world technologies in core areas such as silicon technology and manufacturing; micro architecture and circuits; computing platforms; communications and networking; and software technology (Intel Corporation, n.d).

CIT professionals are key players in making these technologies function in society. The most sought after CIT professionals are those who typically have the following characteristics: are competent in one or more of the core areas mentioned above; can solve a wide variety of technology problems in a variety of situations; and are thought to have good critical thinking skills.

The critical thinking characteristic is especially valued by academics. It is the sort of thinking that is guided by logic and method (*Teaching Critical, n.d.*). Hader (2005, ¶ 6) simply stated:

> Critical thinking can provide you with a more insightful understanding of yourself. It'll offer you an opportunity to be objective, less emotional, and more open-minded as you appreciate others' views and opinions. By thinking ahead, you'll gain the confidence to present fresh perspectives and new insights into burdensome concerns. Thinking critically will boost creativity and enhance the way you use and manage your time.

According to Halpern (1998), good critical thinkers are predisposed to use these skills.

Higher order thinking is often a term used to describe the critical thinking process (Kerka, 1992; Miller, 1990). Halpern (1998, ¶ 10) stated, "Higher order skills are complex and require judgment, analysis, and synthesis and are not applied in a rote or mechanical manner." Simpler skills in comparison are skills that don't require any concern for extraneous variables that would affect the outcome.

A common goal across all disciplines in higher education is to improve critical thinking (Halpern, 1998). Furthermore, van Gelder (2005) suggested that critical thinking is a highly contrived activity that is not natural. It is estimated that only about 25% of first-year college students have the required skills for critical thinking (Halpern, 1996). Halpern (1999) noted, however, that there are identifiable critical thinking skills that can be taught and learned, and when students learn these skills and apply them appropriately, they become better thinkers.

Greenlaw and DeLoach (2003) stated that to effectively teach critical thinking, an instructor must essentially customize the curricula appropriately for each field of study. Fitzgerald (2000), for example, recommended incorporating evaluative skills into the curricula, claiming that that skill is a key component to critical thinking. Lrynock and Robb (1999) subscribed to a curricula change that would incorporate real world, problem-based learning in a cooperative learning setting. Ciardiello (1998) and King (1994) believed that students would benefit in terms of critical thinking when they are given the opportunity to generate their own questions pertaining to the lessons that they learned. Gokhale (1995) and Johnson, Johnson, and Smith (1998) believed in the concept of collaborative learning to enhance critical thinking.

Whatever critical thinking teaching strategies are employed, they need to be worked into the curriculum. It is then necessary to monitor the efficiencies of the curricula with regards to the critical thinking enhancements made. This is typically done using a testing instrument designed to test a student's mental ability (e.g. thinking skills) before and after the student's school term (i.e. two or four years).

The test instrument to be used depends on which type of thinking skills are to be tested. Test instruments will test different thinking skills and will categorize each of these tests into multiple-test categories. Each test will vary, depending on the type of categories tested. For example, the Watson-Glaser Critical Thinking Appraisal (WGCTA) tests for five critical thinking skills (Norris & Jackson, 1992): inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments.

Test instruments that are used to measure critical thinking skills typically require the student to read and evaluate statements that measure various aspects of mental ability. From these measures it is hoped that the quality of the student's critical thinking can be determined, thus forming a baseline in which to measure program effectiveness.

Test instruments that test critical thinking are actually quite versatile. They can be used by more than just teachers and school administrators. Employers and personnel specialists may also find use in the outcome of critical thinking tests. Essentially, anyone who is seeking to measure an individual's capacity for acquiring new knowledge and skills will benefit from using a critical thinking test (York University, n.d.).

As mentioned before, critical thinking tests typically require a pre-test and a post-test to establish analytical data in multiple categories. The pre-test is typically taken in the beginning of a student's two or four year term and the post-test is taken during the student's last semester. A comparison is then made and scores analyzed. The pre-test score typically is not used alone, however, as mentioned above, school guidance counselors may use this score to help them direct the student into taking the correct career path and/or preparatory classes. Besides the WGCTA test instrument just mentioned, there are others such as the Thurstone Test of Mental Alertness, Cornell Critical Thinking Test, and the California Critical Thinking Skills Test (CCTST), to name just a few.

Northcentral Technical College (NTC) of Wausau, Wisconsin, puts high value in the facilitation of learning to individuals, businesses, industries, and organizations with a primary emphasis on building a competitive workforce in a changing global society (Northcentral, n.d.). NTC offers career preparation in some of the fastest-growing fields in the U.S. today. Students can choose from more than 40 one- and two-year programs and be virtually assured of a job when they graduate. NTC has 45 advisory committees, with representatives from business and industry, which continually monitor degree and certificate programs to ensure that they are up to date and meet the needs of employers.

This research is essentially a part of the continuous improvement efforts of NTC and its' advisory boards and is concerned primarily with the results of administering the CCTST within the CIT unit at NTC.

*Statement of the Problem*

The administration of critical thinking teaching methodologies has been occurring for numerous years within the CIT unit at NTC, but no evaluation has been conducted pertaining to the effectiveness of these methodologies.

*Purpose of the Study*

The purpose of this study is to use the CCTST assessment tool on a CIT unit of instruction at NTC to measure the effectiveness of critical thinking teaching methodologies. The CCTST assessment tool has been administered by NTC since August of the year 2000. Analysis of the CCTST results was done during the 2005-2006 school year.

*Research Questions*

This study will address the following research questions:

1. Is there a significant difference between the pre-CCTST results and the post-CCTST results within the entire CIT unit at NTC?

2. Is there a significant difference between the pre-CCTST results and the post-CCTST results when compared within each specific CIT sub-unit at NTC?

3. How does the entire CIT unit at NTC compare with a CIT unit at another technical college within the state of Wisconsin?

*Importance of the Study*

This research is important for the following reasons:

1. The statistics from the CCTST will provide NTC with a starting point in determining the effectiveness of their CIT program with regards to the influence the program has on the students' critical thinking skills. The results from this test will give NTC scientific reasoning behind the need to change or not change their curriculum to enhance students' critical thinking skills.

2. As an added benefit of administering the CCTST, NTC will also be able to direct students into coursework that will orient the students correctly to enhance their learning and to ensure retention. This can be done based on pre-CCTST results. Pre-CCTST results can point out any potential weaknesses and thus allow guidance and counseling personnel to recommend or

require remedial classes to improve upon those weaknesses. Consequently, students who are good critical thinkers will be less likely to drop out of the program.

3. Critical thinking is the foundation of computer science and other disciplines; it is essential that computer science programs incorporate learning and teaching activities with a focus on critical thinking. As stated by Weinstein (n.d., ¶ 18):

> Critical thinking seeks to move post-secondary educators from gate-keeping and towards the identification of methods and attitudes that help all students to achieve the standards of intellectual excellence and practical wisdom required for full participation in the economic and political life of society.

4. Ensuring that critical thinking is well defined in the course will help students face crucial decisions in education and in life. Critical thinking skills will help students be more inquisitive, systematic, judicious, analytical, truth seeking, open-minded, and confident in reasoning (Facione, 1998).

*Limitations of the Study*

The following limitations are noted for this study:

1. The scope of the critical thinking study encompasses only the enrolled CIT students at NTC. Generalizations should not be made to other programs.

2. Students who enter the CIT track are asked to take the CCTST test in their first and fourth semesters. However, due to uncontrolled circumstances, some students do not take the pre-CCTST, the post-CCTST, or both.

3. The post-CCTST is administered at the end of the fourth semester during a time that many students may not give the test their undivided attention due to other factors such as final exams and graduation.

4. The post-CCTST is the same as the pre-CCTST. Students therefore may be alerted to the questions, consequently losing some test integrity.

5. Test results may not always be attributed to instruction. Outside influences such as students' family, neighbors, and friends may play a big role on how well a student scores on the pre-test and/or post-tests during this study – and is one reason why comparing the scores from one school against another may not be reliable.

6. Since the test is timed, a student's reading level may attribute to poor test results.

*Definition of Terms*

The following is a definition of key terms in this research:

1. Analysis: "Is the ability to examine ideas and break down arguments into smaller units in an effort to fully understand meanings and relationships between ideas" (California, n.d., p. 2).

2. Collaborative learning: Gokhale (1995) states that collaborative learning is when two or more people are grouped for the purpose of achieving an academic goal.

3. Computer Science: This defines the discipline that is concerned with methods and techniques relating to automated data processing (Atis, 2000).

4. Critical Thinking: "Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Scriven & Paul, 2004., ¶ 1).

5. Curriculum: "A set of courses and their contents offered by an institution such as a school or university" (Answers, n.d., ¶ 1).

6. Deductive Reasoning: "Is logic that moves from the general to the specific"

(Shumate, N., Creek, L., & Crittenden, E., 2001).

7. Evaluation: "Is the ability to assess the credibility and strength of claims and arguments as well as the ability to state one's findings, explain the reasoning behind the findings, and to present this in a clear and logical manner" (California, n.d., p. 2).

8. Inductive Reasoning: "Drawing a general conclusion based on a limited set of observations" (Thomson, n.d.).

9. Inference: "Is the ability to question evidence, come up with alternatives, and draw conclusions. This includes the ability to both identify and consider needed elements and to form hypotheses" (California, n.d., p. 2).

# Chapter II

## Literature Review

This chapter will include a discussion of critical thinking concepts, followed by descriptions of various educational methods known to be effective in enhancing critical thinking in the classroom. The chapter will conclude with an overview of critical thinking assessment techniques and sources.

### *Critical Thinking Concepts*

Critical thinking is a learned skill (Halpern, 1999; Schafersman, 1991; van Gelder, 2005). The investigative techniques necessary to do this research thesis, for example, are learned techniques and clearly mimic the high-order thinking involved in critical thinking: define a problem or question, form a hypothesis, collect data, analyze the data, and draw conclusions and interpretations. Low-order thinking, such as many common, everyday survival tasks are not examples of critical thinking.

Most humans are constantly processing information; however, critical thinking is not always involved in this process. As Schafersman (1991, ¶ 15) stated:

> Critical thinking is the practice of processing this information in the most skillful, accurate, and rigorous manner possible, in such a way that it leads to the most reliable, logical, and trustworthy conclusions, upon which one can make responsible decisions about one's life, behavior, and actions with full knowledge of assumptions and consequences of those decisions.

Critical thinking experts define critical thinking in many different ways. To clarify matters, Dr. Peter Facione was asked by the American Philosophical Association, through its Committee on Pre-College Philosophy, to make a systematic inquiry into the current state of critical thinking and critical thinking assessment (Facione, 1990). Dr. Facione chose a panel of 46 experts (hereafter referred to as the panel) and performed his research using the Delphi method. Dr. Facione named his report The Delphi Report. The panel consisted of professionals in the following areas: philosophy (52%), education (22%), social sciences (20%), and physical sciences (6%). The consensus on critical thinking was made using two dimensions: cognitive and disposition.

Within the cognitive dimension, the panel identified six skills that they considered core to critical thinking. Appendix A itemizes the panel's consensus list of critical thinking cognitive skills and sub-skills. A person characterized with some or all of these skills and sub-skills determine his or her ability to think critically.

With regard to the disposition dimension, most of the panel agreed that good critical thinkers could be characterized as exhibiting the dispositions listed in Appendix B. A person with some or all of these dispositions determines that person's inclination for thinking critically.

The quantity of critical thinking cognitive skills a person has will determine the degree at which that person can be characterized as being a critical thinker and how strong the critical thinking dispositions are of that person. In other words, a person can still be considered a critical thinker if that person possesses just a portion of the above skills and dispositions, that person just won't be considered a good critical thinker.

*Critical Thinking in the Classroom*

Students can become better, lifelong thinkers as a result of appropriate instruction (Halpern, 1998). To meet the needs of an ever changing, highly competitive world, it is essential that students be taught the skills of critical thinking. Halpern (1998, ¶ 7) stated, "the rate at which knowledge has been growing is exponential, and the most valued asset of any society in the coming decades is a knowledgeable, thinking citizenry—human capital is the wisest investment."

There are many thoughts on critical thinking teaching methodologies. When developing a critical thinking focus into a new or existing curriculum, both of the divisions as defined by The Delphi Report should be considered.

*Dispositional or Attitudinal Focus*

It is imperative to treat the disposition component (Appendix B) separate from the critical thinking skills component (Appendix A). Having excellent critical thinking skills is not enough, people also need to be able to recognize when the skills are needed and choose to use those skills (Facione, 1990; Halpern, 1998). Halpern suggested that instructional programs should help learners decide when it is time to use or not use critical thinking.

The enhancement of student's critical thinking dispositions will not likely come from specific instruction on critical thinking dispositions. Emphasis on thinking styles in academic programs, for example, has shown promise in numerous studies to strengthen critical thinking dispositions. Other studies (Bostic; Gadzell; Marra; cited in Zhang, 2003) show this relationship. Zhang's study (2003) uses R.J. Sternberg's thinking styles theory as a basis for his research. Sternberg's theory, according to Zhang, consisted of 13 different thinking styles and is described using examples in Appendix C. Of these thinking styles, the styles that influence creativity, necessitate higher levels of thinking, and should be given emphasis include: legislative, judicial, hierarchical, global, and liberal styles.

*Critical Thinking Skills Focus*

The ideal goal in education is to teach critical thinking skills in a way that will enable these skills to transfer into a multitude of real world situations in the work place. There are many studies describing critical thinking instructional methodologies. The following list summarizes the most prominent of these methodologies and could easily be incorporated into a rubric to assist the instructor in assessing their critical thinking teaching methods.

1. Promote active learning in a group setting. This gives students an opportunity to be accountable, to learn from others, and to enhance their critical thinking skills (Gokhale, 1995; Johnson, Johnson, and Smith, 1998).

2. Promote student-generated questions. Evidence suggests that higher-order thinking skills are used when students formulate their own questions (Ciardiello, 1998; King 1994).

3. Probe student's thinking using open-ended questions. This has a tendency to make students think more analytically and thus use higher order thinking skills (Potts, 1994).

4. Promote the transfer of acquired critical thinking skills by linking the need of a particular newly acquired skill to other situations and perhaps the student's own experiences (Halpern, 1998).

5. Promote the evaluation (critique) of information. Evaluative skills use reasoning (being more critical of information), argument analysis (comprehension and coping with the complex nature of arguments), and scientific analysis (forming a hypothesis, collecting data, analyzing the data and then making conclusions) (Fitzgerald, 2000; Halpern, 1998, 1999).

6. Promote decision-making and problem solving (Halpern, 1998; Lrynock & Robb, 1999). This skill essentially involves the ability of a person to intelligently judge between alternatives in a problem situation - real world scenarios being the most effective.

Regardless of the discipline and how many of the above strategies are placed in the curriculum, teaching critical thinking skills must teach students how to think in a controlled, disciplined manner. According to Paul and Elder of the National Council for Excellence in Critical Thinking (NCECT) (2004), students should be given the opportunity and encouragement to think for themselves utilizing defined standards such as clarity, accuracy, precision, relevance, depth, breadth, and logic. Instructors should continually ask questions to probe student thinking, to make them accountable for their thinking, and to help engrain a desire to be good critical thinkers. Consequently, instructors must also be good critical thinkers.

*Critical Thinking Assessment*

Critical thinking can take on many different definitions, but largely mean the same thing. Critical thinking is basically a form of thinking used in problem solving scenarios and uses knowledge acquired over a lifetime in a manner that is logical. This form of thinking demonstrates the skills dimension of critical thinking (Facione, 1998).

Academic institutions that implement critical thinking in their curriculum must continually strive to fine-tune their procedures. To insure their program is meeting the needs of critical thinking instruction, schools must assess their students on the critical thinking skills learned during their school term.

One form of critical thinking assessment is the California Critical Thinking Skills Test (CCTST). The CCTST targets the core critical thinking skills outlined in Appendix A: analysis, interpretation, inference, evaluation, and explanation. Several scores are generated by the CCTST as follows: total score; inductive and deductive reasoning sub-scale scores; and sub-scale scores relating to the categories of analysis, inference, and evaluation (Facione, 1998). The test questions are carefully worded to invite test takers to draw upon their long-term memory store and to exercise their critical thinking skills in the above areas. The CCTST scores can be compared against national norms and internally established norms for different groups of test takers. The CCTST can be used for learning outcomes assessment, performance funding, program evaluation, professional development, training, and as an element in application, admissions, and personnel evaluation processes (Insight, n.d.).

The Watson-Glaser Critical Thinking Appraisal (WGCTA) is another assessment tool designed to measure an individual's critical thinking skills. Like the CCTST, the WGCTA is a paper & pencil based test used by educational and organizational entities. The WGCTA has an array of problems, statements, arguments, and interpretations that assess the test-takers critical thinking skills. The critical thinking skills of inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments are assessed by the WGCTA using just one score (Performance, n.d.).

The two critical thinking assessment tests mentioned above measure more than one aspect of critical thinking. There are other tests that are similar such as the Cornell Critical Thinking Tests, the Ennis-Weir Critical Thinking Essay Test, the New Jersey Test of Reasoning Skills, and the Ross Test of Higher Cognitive Processes, to name just a few (Ennis, 1993).

Critical thinking assessment tests are certainly not to be treated equal. Ennis (1993) believes that there are few critical thinking assessment tests that incorporate critical thinking as their primary concern. Furthermore, he believes that critical thinking assessments fail to assess important, creative components of the thinking process like open mindedness, judging credibility of sources, conceiving of alternatives, formulating hypothesis and definitions, and developing plans for experiments. According to Ennis, this is primarily due to critical thinking assessments being written in multiple-choice questions versus short answer or essay.

*Summary*

Educational institutions, especially colleges and universities, have a key role in developing critical thinking skills. Critical thinking skills are in high demand by business and industry. Even though students are not necessarily conscious of their critical thinking skills development and instructors may have differing approaches to critical thinking teaching methodologies, critical thinking in general will always be an essential cognitive prerequisite for a student to be successful in his or her career. Consequently, an assessment of the effectiveness of institutional critical thinking teaching methodologies is an essential element to the continuous improvement efforts that most institutions practice.

# Chapter III

## Methodology

This chapter discusses the methodology by which the Computer Information Technology (CIT) unit of Northcentral Technical College (NTC) of Wausau, Wisconsin conducted their assessment of student critical thinking. The chapter begins with a description of the research method used by NTC, followed by the selection of subjects, instrumentation details, data collection procedures, data analysis procedures, and finally the limitations of the methodology.

### *Description of the Research Method*

The method of this study is causal-comparative. The independent variable in this study is the method of instruction. The dependent variables are both the pre-test scores and the post-test scores from the California Critical Thinking Skills (CCTST) assessment tool. The results of each group will be compared to determine whether or not there is a possible correlation with the method of instruction and growth in critical thinking skill level.

### *Selection of Subjects*

The population for this study consisted of CIT associate degree candidates enrolled at NTC since August of 2000.

### *Instrumentation*

The instrument of choice for NTC's study was the California Critical Thinking Skills Test (CCTST). As the name implies, this is a critical thinking skills test and not a test of critical thinking disposition. The CCTST is considered a discipline-neutral measurement device and is designed for use with adults at community colleges as well as with undergraduate, graduate, and professional school levels (Facione, Facione, Blohm, Howard, & Giancarlo, 1998). The CCTST comes in multiple forms (Form 2000, Form A, and Form B), each having different published dates (2000, 1990, 1992, respectfully). All forms have 34 multiple-choice questions. Questions test core critical thinking skills. The scores returned from CCTST are categorized into sub-scales as follows: analysis, evaluation, inference, deductive reasoning, and inductive reasoning. The CCTST test manual describes a norm reference group of 781 college students and provides information on concurrent validity, content validity, and internal reliability.

In terms of concurrent validity, the CCTST test manual (Facione et al., 1998) reflects on numerous studies that have shown a correlation between CCTST and other testing instruments such as the Watson-Glaser Critical Thinking, SAT verbal and math scores, and the Nelson-Denny reading test. The CCTST manual also reports that the CCTST has a strong correlation with both college level grade point average and the Graduate Record Examination.

The basis by which there is content and construct validity stems from the fact that each question in the CCTST, according to the CCTST manual (Facione et al., 1998), was formulated carefully based on a theoretical relationship to the critical thinking skills and sub-skills defined by the panel of experts in The Delphi Report (Appendix A).

Reliability of the CCTST was established using Kuder-Richardson Formula 20 (KR 20) coefficients for internal consistency. The CCTST ranged from .78 to .84 (Form 2000) and .70 to .75 (Form A and B) (Insight, n.d.). Internal consistency focuses on the degree to which the individual items are correlated with each other (Rudner & Schafer, 2001). According to Rudner and Schafer, most large-scale tests have coefficients that are greater than .80. Even though the CCTST forms tend to be less than .80, according to Facione et al. (1998), this is due to the fact that the CCTST assesses numerous abilities (versus a single ability) and therefore states the CCTST to be internally reliable.

*Data Collection Procedures*

The CIT students selected for this study were given a pre-test during their first semester in a required class. All pre-tested students were given the same test just prior to graduation in a required class that is typically taken during the students' fourth semester.

*Data Analysis Procedures*

The data was analyzed primarily to identify statistical significant differences between the pre-test CCTST and the post-test CCTST results of CIT students at NTC. This analysis will be done using the mean (average) of each test (pre and post) and will differentiate the pre-test and post-test means within the CIT unit as a whole and between the programming and networking CIT sub-units. To determine significance, this researcher chose independent t-tests at a probability level .05 (95% confident that the data did not happen by chance).

*Limitations*

The following limitations are noted for this methodology:

1. The scope of the critical thinking study encompasses only the enrolled CIT students at NTC. Generalizations should not be made to other programs.

2. Students who enter the CIT track are asked to take the CCTST test in their first and fourth semesters. However, due to uncontrolled circumstances, some students do not take the pre-CCTST, the post-CCTST, or both.

3. The post-CCTST is administered at the end of the fourth semester during a time that many students may not give the test their undivided attention due to other factors such as final exams and graduation.

4. The post-CCTST is the same as the pre-CCTST. Students therefore may be alerted to the questions, consequently losing some test integrity.

5. Test results may not always be attributed to instruction. Outside influences such as students' family, neighbors, and friends may play a big role on a student's critical thinking skills – and is one reason why comparing the scores from one school against another may not be reliable.

6. Since the test is timed, a student's reading level may attribute to poor test results.

*Summary*

The world is changing very rapidly and is becoming more complex everyday. This fact of life is forcing many people to realign their thinking strategies to survive. The essential component of thinking called critical thinking could quite possibly be the deciding factor between those that are successful and those that are not. Seeing this need to improve critical thinking, educators across the country are working diligently to improve the critical thinking component in their curriculum. For these educators to be successful, however, a routine of critical thinking skills assessment must be performed to evaluate the progress educators are making in their endeavors.

The statistics from this research will certainly give the CIT unit at NTC long awaited answers on the effectiveness of their curriculum with regards to critical thinking; it may also trigger school wide use of CCTST for the benefit of all.

# CHAPTER IV

## Results

The purpose of this study is to use the California Critical Thinking Skills Test (CCTST) assessment tool on a computer information technology (CIT) unit of instruction at Northcentral Technical College (NTC) to measure the effectiveness of critical thinking teaching methodologies. This chapter will address this purpose by analyzing the statistical differences between students' CCTST scores that were obtained when they first entered the CIT program (pre-test) and those CCTST scores that were obtained from the same students as they were preparing to graduate (post-test).

### *Data Analysis*

In this study there were 283 CCTST tests completed by 252 participants from all three CIT units at NTC – computer support, programming and networking. Sixty of these tests (21%) had the same participant taking both the pre-test and the post-test, representing two CIT units at NTC – programming and networking. This chapter will analyze the statistical data from these 60 tests using the following three distinct sections: a combined CIT unit analysis, an individual CIT unit analysis, and then finally a comparison will be made between NTC's combined CCTST CIT unit data and the combined CCTST CIT unit data that was derived from a similar study done in 2000 at the Nicolet Area Technical College (NATC).

In the combined CIT unit analysis and the individual CIT unit analysis, the CCTST scores will be represented in six categories: total score, analysis, evaluation, inference, deductive reasoning, and inductive reasoning. The total score represents the overall critical thinking skills of the participants. The analysis, evaluation, and inference sub-scales represent a portion of the critical thinking skills defined by the panel of experts in The Delphi Report (Facione, 1990). The inductive reasoning and the deductive reasoning sub-scales also evaluate critical thinking skills, but in more traditional ways.

Since this study is based on statistical data from independent groups (pre-tests and post-tests), group means for pre-test scores and a group means for post-test scores were used in the analysis. To determine statistical significance, a t-test was used at a probability level of .05.

*Combined CIT Unit Analysis*

*Total Mean Scores*

The combined total mean scores for both CIT networking and programming students showed a positive change from 14.13 to 14.43. This data did not yield significant results (p > .05). See Figure 1.

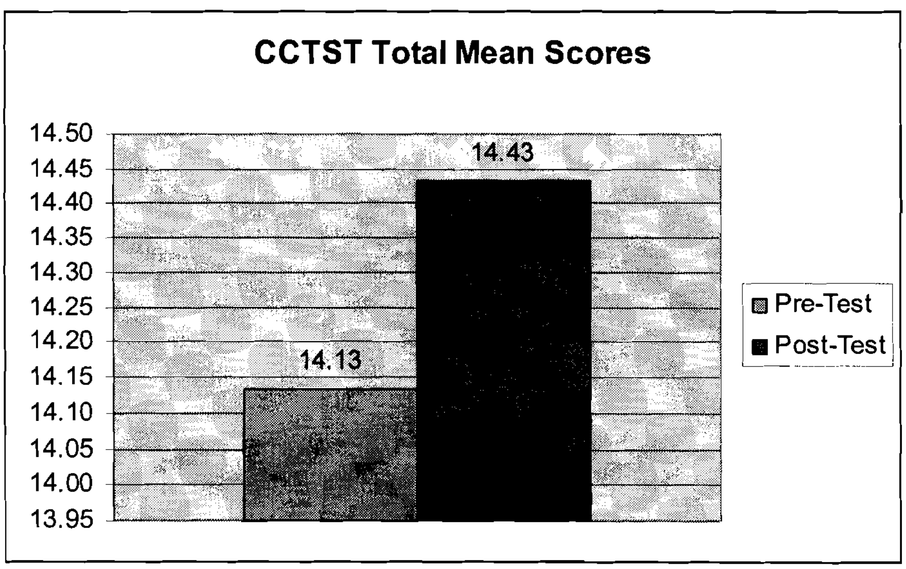


Figure 1

*Analysis Sub-Scale Mean Scores*

The combined analysis sub-scale mean scores for both CIT networking and programming students showed a positive change from 4.30 to 4.43. This data did not yield significant results (p > .05). See Figure 2.

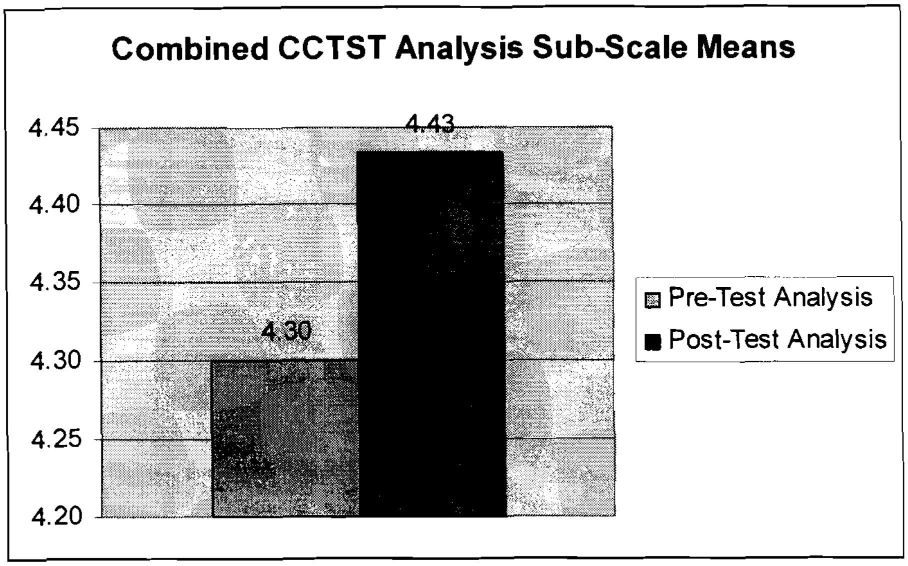


Figure 2

*Evaluation Sub-Scale Mean Scores*

The combined evaluation sub-scale mean scores for both CIT networking and programming students showed a positive change from 4.70 to 5.20. This data did not yield significant results ($p > .05$). See Figure 3.

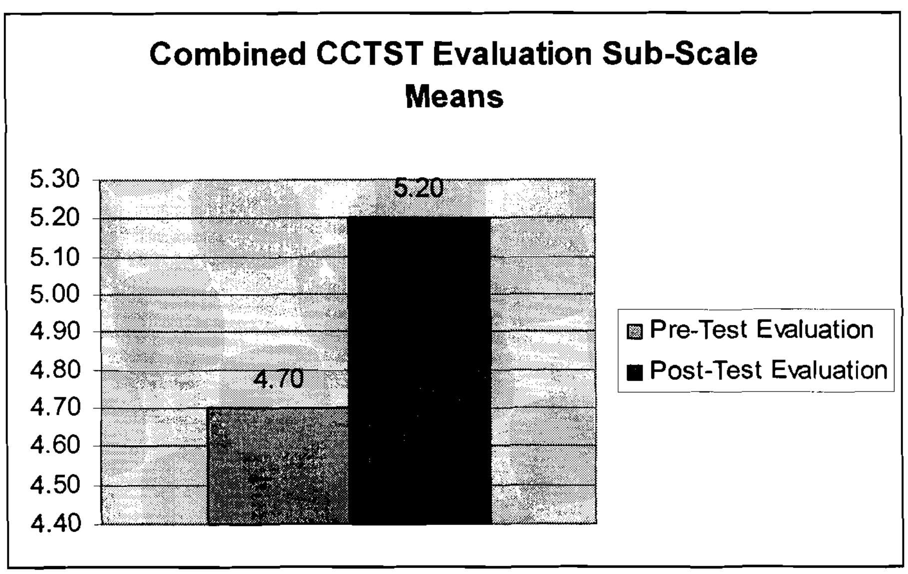


Figure 3

*Inference Sub-Scale Mean Scores*

The combined inference sub-scale mean scores for both CIT networking and programming students showed a negative change from 5.13 to 4.80. This data did not yield significant results ($p > .05$). See Figure 4.

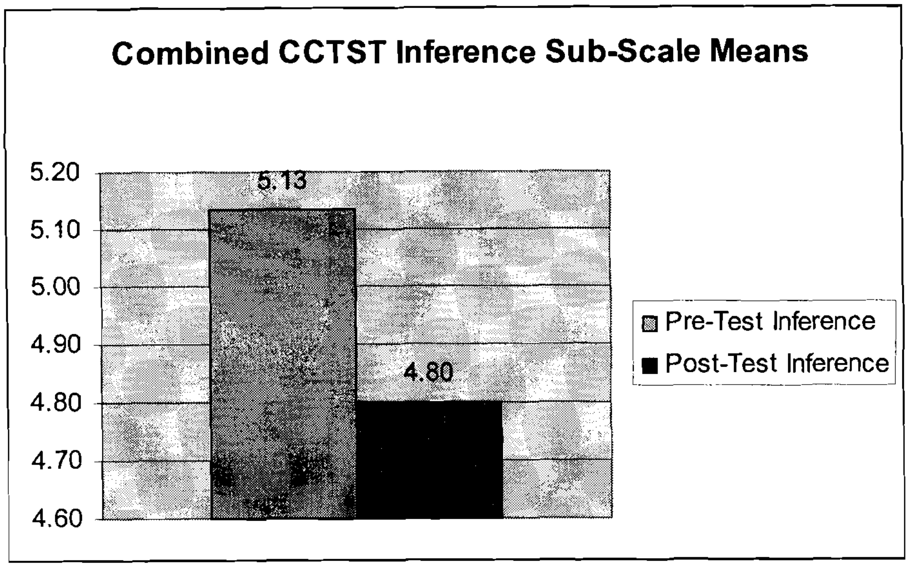


Figure 4

*Deductive Sub-Scale Mean Scores*

The combined deductive sub-scale mean scores for both CIT networking and programming students showed a negative change from 7.20 to 7.10. This data did not yield significant results ($p > .05$). See Figure 5.

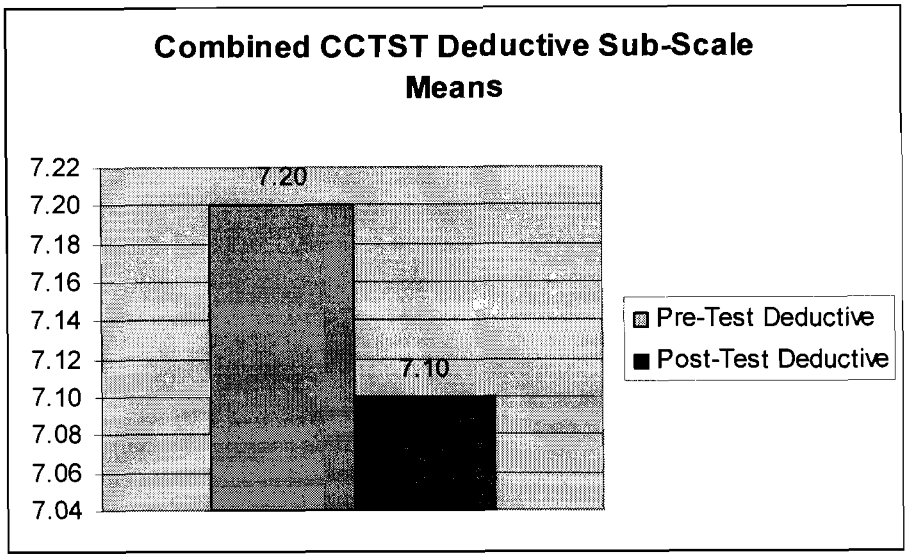


Figure 5

*Inductive Sub-Scale Mean Scores*

The combined inductive sub-scale mean scores for both CIT networking and programming students showed a positive change from 5.23 to 5.47. This data did not yield significant results ($p > .05$). See Figure 6.

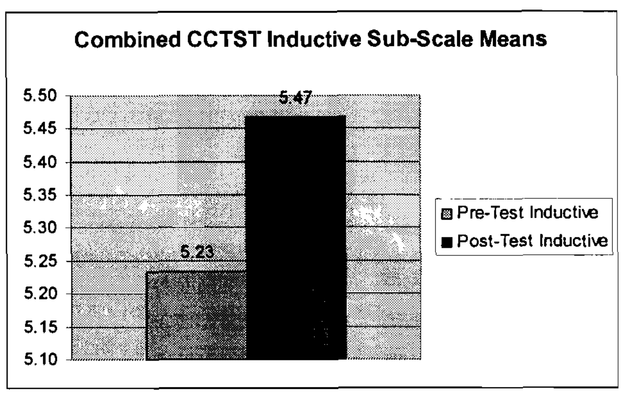


Figure 6

*Individual CIT Unit Analysis*

*Total Mean Scores*

When categorized by specific CIT units, the total mean scores for NTC's CIT programming students showed a negative change from 14.85 to 13.69 (n = 13), while the total mean scores for CIT networking students showed a positive change from 13.59 to 15.00 (n = 17). This data did not yield significant results (p > .05). See Figures 7 and 8.

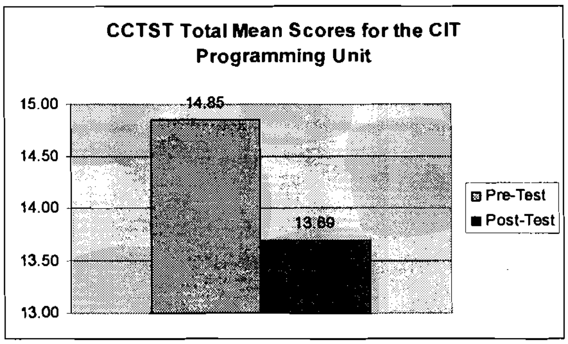


Figure 7

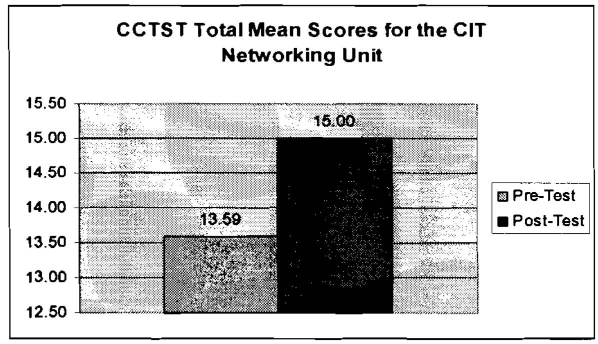


Figure 8

*Analysis Sub-Scale Mean Scores*

The analysis sub-scale mean scores for CIT programming students showed a negative change from 4.69 to 4.38 (n = 13), while the analysis sub-scale mean scores for CIT networking students showed a positive change from 4.00 to 4.47 (n = 17). This data did not yield significant results (p > .05). See Figures 9 and 10.

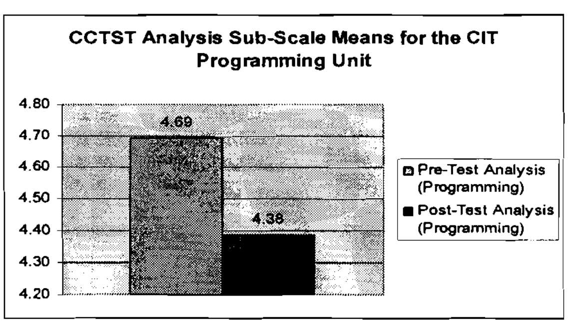


Figure 9

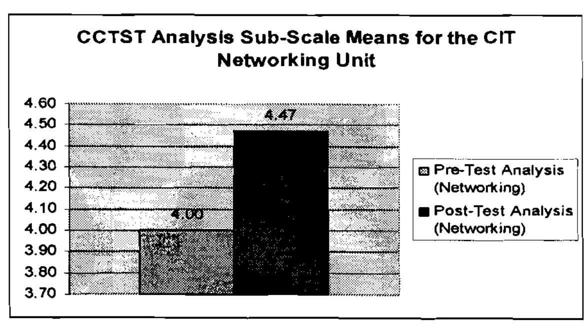


Figure 10

*Evaluation Sub-Scale Mean Scores*

The evaluation sub-scale mean scores for CIT programming students showed a negative change from 5.15 to 4.69 (n = 13), while the evaluation sub-scale mean scores for CIT networking students showed a positive change from 4.35 to 5.59 (n = 17). This data did not yield significant results (p > .05). See Figures 11 and 12.

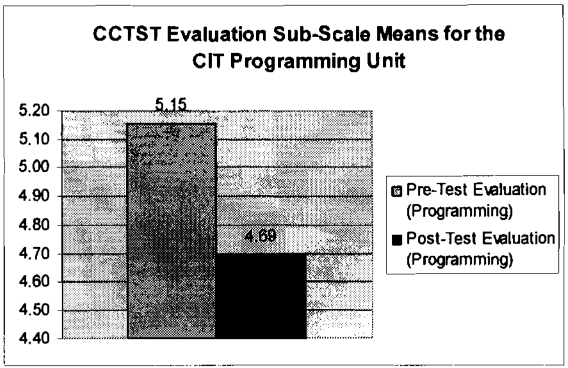


Figure 11

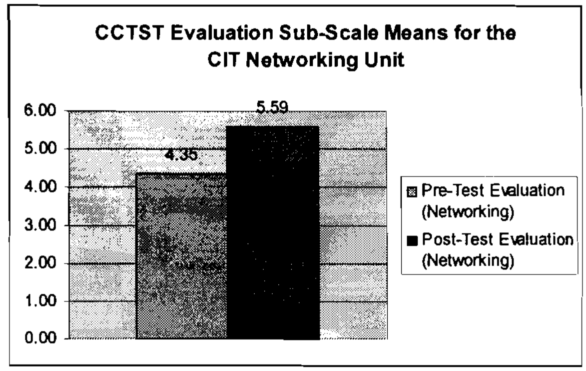


Figure 12

*Inference Sub-Scale Mean Scores*

The inference sub-scale mean scores for CIT programming students showed a negative change from 5.00 to 4.62 (n = 13). The inference sub-scale mean scores for CIT networking students also showed a negative change, with the mean changing from 5.24 to 4.94 (n = 17). This data did not yield significant results (p > .05). See Figures 13 and 14.

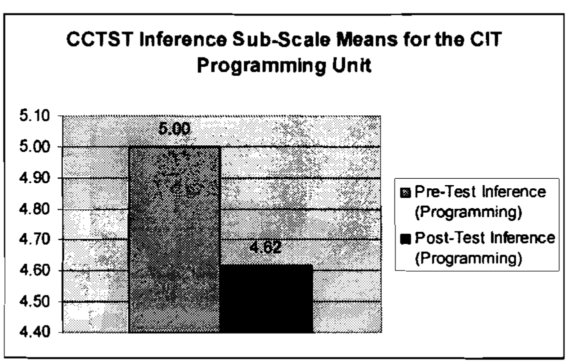


Figure 13

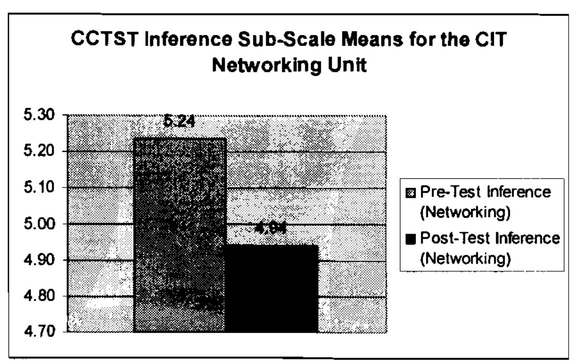


Figure 14

*Deductive Sub-Scale Mean Scores*

The deductive sub-scale mean scores for CIT programming students showed a negative change from 7.31 to 6.46 (n = 13), while the analysis sub-scale mean scores for CIT networking students showed a positive change from 7.12 to 7.59 (n = 17). This data did not yield significant results (p > .05). See Figures 15 and 16.

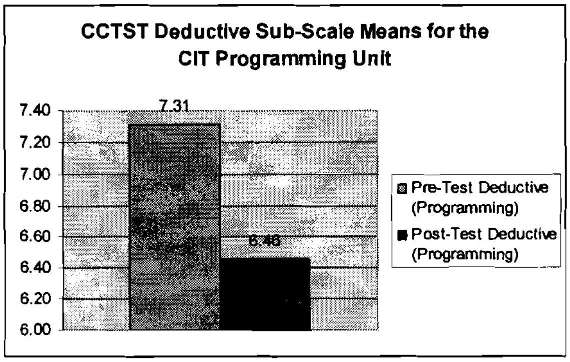


Figure 15

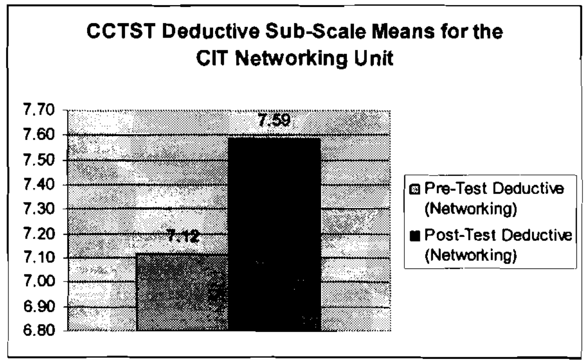


Figure 16

*Inductive Sub-Scale Mean Scores*

The inductive sub-scale mean scores for CIT programming students showed a negative change from 5.38 to 5.08 (n = 13), while the inductive sub-scale mean scores for CIT networking students showed a positive change from 5.12 to 5.76 (n = 17). This data did not yield significant results (p > .05). See Figures 17 and 18.

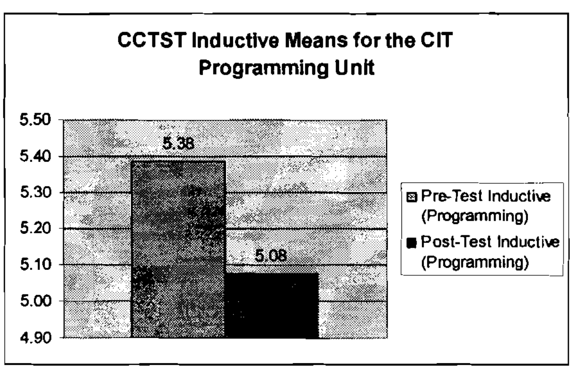


Figure 17

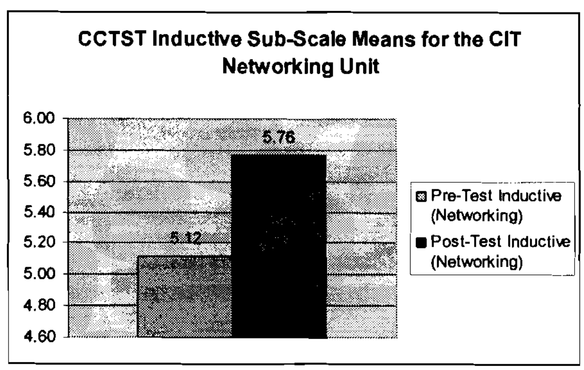


Figure 18

*Combined CIT Unit Analysis between NTC and NATC*

Figure 19 shows a comparison between the combined CCTST total mean scores from both NTC's programming and networking units and the combined CCTST total mean scores from NATC's programming, networking and computer support units (Raykovich, 2000). Both NTC and NATC are within the Wisconsin Technical College System and share district borders. The data from NTC's study did not yield significant results ($p > .05$), while the data from NATC's study did ($p < .05$).

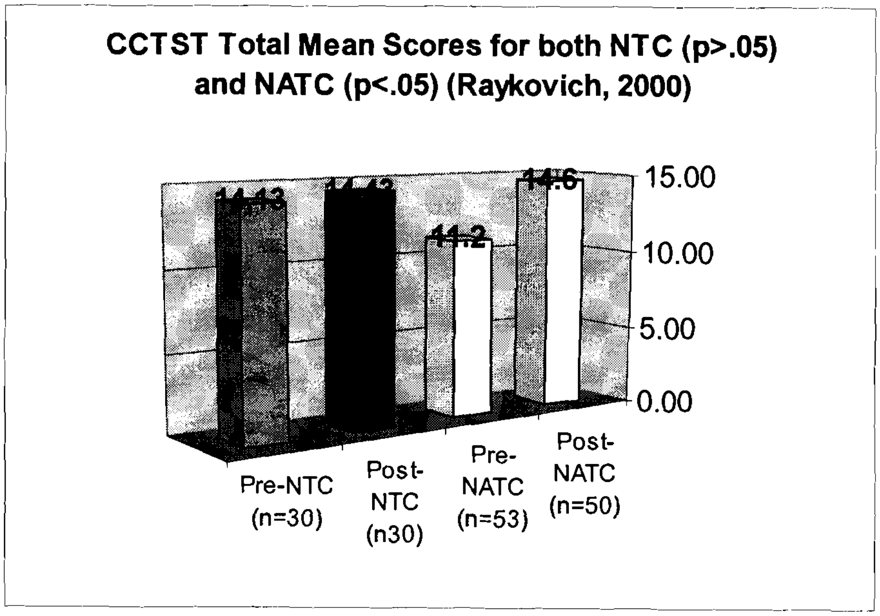


Figure 19

# CHAPTER V

## Summary of Findings

This chapter will first briefly summarize the significance of critical thinking skills as they relate to instructional design and restate the purpose of this study. The results of this project will then be interpreted and some conclusions will be made as they relate to the research questions posted in chapter one. Finally, some recommendations will be made for further study in the area of critical thinking assessment and critical thinking teaching strategies.

### *Summary of the Study*

Because of the rapid change in computer technology, computer information technology departments in educational institutions throughout the world have to keep pace. Often times keeping pace means to revamp Computer Information Technology (CIT) degrees and certificates to help provide graduates with competitive job skills and to provide employers with a productive workforce. What should not be overlooked in favor of tangible skills like programming, networking, and computer support is emphasis on what may very well be the most important component to a well rounded CIT curriculum – critical thinking.

Based on the information gathered in this research project, instructors and curriculum design staff in all areas of education should infuse at least a recognizable amount of learning tasks into the curriculum that will enhance critical thinking ability. According to Halpern (1998), to meet the needs of an ever changing, highly competitive world, it is essential that students be taught the skills of critical thinking.

Critical thinking, according to van Gelder (2005), is not a natural tendency, it must be learned. Halpern (1999) believes that critical thinking skills can be taught and learned through instruction. Many schools across the country are attempting to improve critical thinking

(Halpern, 1998). To measure the effectiveness of these improvements, these schools need to assess student's critical thinking before and then after critical thinking instruction takes place (causal-comparative). There are many critical thinking assessment tests available that will effectively measure critical thinking skills in this manner. Examples of these critical thinking assessment tests include the Watson-Glaser Critical Thinking Appraisal (WGCTA) test, the Thurstone Test of Mental Alertness, the Cornell Critical Thinking Test, and the California Critical Thinking Skills Test (CCTST).

The purpose of this study is to use the CCTST assessment tool on a CIT unit of instruction at Northcentral Technical College (NTC) to measure the effectiveness of critical thinking teaching methodologies.

*Interpretation of Results*

This study was in progress since August of the year 2000 and involved 252 students from all three CIT units at NTC - computer support, networking, and programming. The goal of this researcher was to give a detailed analysis on only those students who participated in both the CCTST pre-test and the CCTST post-test - only 30 students, representing just the programming and networking units, satisfied this requirement. It is the data from these 30 students that will be used to answer the following research questions:

*Research question #1: Is there a significant difference between the pre-CCTST results and the post-CCTST results within the entire CIT unit at NTC?*

The combined CCTST total scores and the five sub-scale scores of analysis, evaluation, inference, deductive reasoning, and inductive reasoning from both CIT units (programming and networking) statistically showed no significant change from the pre-test CCTST scores to the post-test CCTST scores ($n = 30$, $p > .05$). Based on this data, if no limitations are applicable (see chapter 1), a conclusion can be made that the critical thinking teaching methodologies used in both the programming and the networking units at NTC did not enhance the critical thinking of the students during the time period of this study.

In further analyzing the individual total scores, 43% of the students in the study had a CCTST post-test total score that was less than the CCTST pre-test total score (see Figure 1). Since critical thinking is a learned skill (Halpern, 1999; Schafersman, 1991; van Gelder, 2005) and becomes part of a student's long-term memory (Bruning, Schraw, Norby, & Running, 2004), it is unlikely that critical thinking ability will actually decrease in the 2 years that the test participants are in the study. Based on this assumption, it is more likely that the tests in this 43% category were not taken seriously by the test participants or perhaps there were outside influences that played a role in the outcome, as stated in the limitations of this study. Further research and/or precautions should be taken in this area to ensure accurate data.

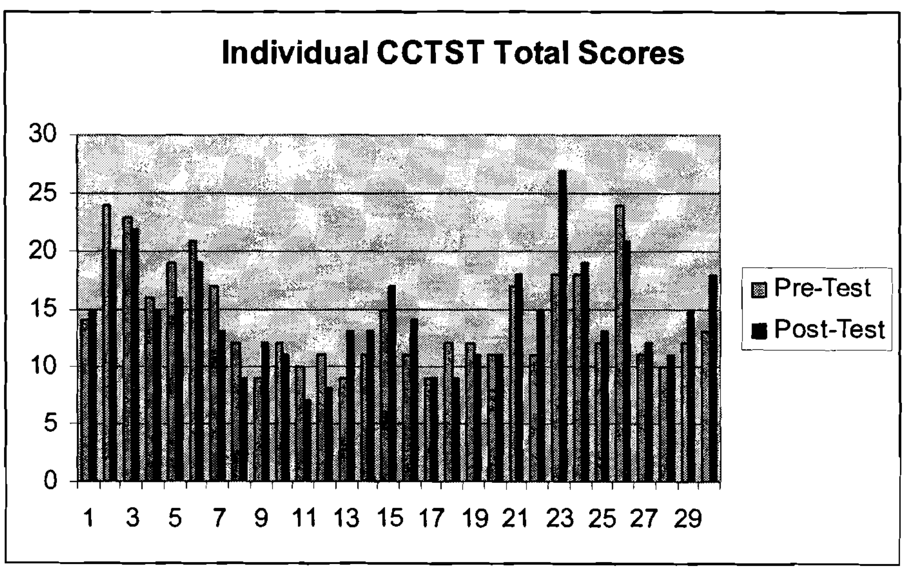


Figure 1

Even though the five sub-scale means showed no significant changes between the pre-test and the post-tests, it is worth noting that the inference and the deductive sub-scale means actually decreased from pre-test to post-test, while the other sub-scale means showed a positive change. Further research and curriculum development in these areas may need to be considered.

*Research question #2: Is there a significant difference between the pre-CCTST results and the post-CCTST results when compared within each specific CIT sub-unit at NTC?*

The CCTST total scores and the five sub-scale scores of analysis, evaluation, inference, deductive reasoning, and inductive reasoning as compared from within each specific CIT unit (programming and networking) statistically showed no significant change from the pre-test CCTST scores to the post-test CCTST scores ($p > .05$). Based on this data, if no limitations are applicable, a conclusion can be made that the critical thinking teaching methodologies used in both the programming and the networking units at NTC did not enhance the critical thinking of the students during the time period of this study.

Despite this lack of statistical significance, the programming unit showed a consistent negative change from pre-test scores to the corresponding post-test scores, while the networking group consistently showed positive gains. Based on the individual CCTST total test scores, 62% of participants in the programming group showed a negative change (see Figure 2), while only 24% in the networking group showed a negative change (see Figure 3).

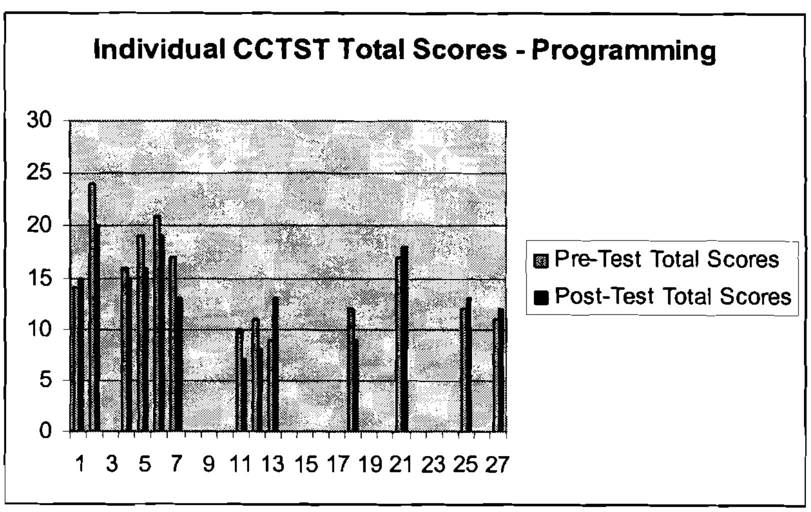

Figure 2

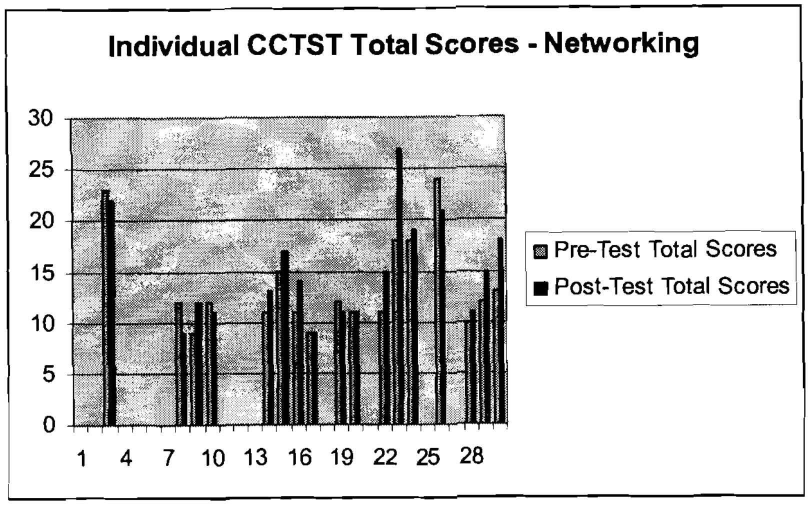


Figure 3

There is no reason to believe that the networking students are any more capable of critical thinking than the programming students. What this trend may indicate is that perhaps the administration of CCTST itself needs some improvements. An effort should be made to identify the limitations of this study that could be causing this negative outcome and then make the necessary adjustments before the CCTST is administered again.

Based on the observed t-tests, the analysis sub-scale means and the evaluation sub-scale means within the networking group showed the most promise. It is interesting to note that if the probability level of the t-test was set to .1 for this study, the evaluation sub-scale means would actually show a statistically significant change ($df = 32$, $p < .05$).

*Research question #3: How does the entire CIT unit at NTC compare with a CIT unit at another technical college within the state of Wisconsin?*

The Nicolet Area Technical College (NATC), NTC's district neighbor, had done a nearly identical study in 2000. The CCTST pre-test total mean scores were considerably different (14.13 for NTC and 11.2 for NATC), while the CCTST post-test total mean scores were surprisingly very similar (14.43 for NTC and 14.6 for NATC).

Both studies used a t-test with a probability of .05 to test significance, only the NATC study showed statistical significance (df = 101, $p < .05$). However, due to the similarities each school has with regards to their CIT infrastructures, the fact that both CCTST post-test totals were very similar, adds more legitimacy to the findings.

*Recommendations*

There are many limitations that can seriously affect the outcome of research on critical thinking – especially when the research is a causal-comparative study based on pre-test and post-test dependent variables. Because some of these limitations have appeared to affect this study and quite possibly were the reason for statistical insignificance in all of the categories analyzed, the statistics from this study can only marginally play a role in determining the effectiveness of NTC's CIT unit's effort in teaching critical thinking skills.

If the CIT unit of NTC wishes to pursue further critical thinking assessment, further research needs to be done to minimize the role these limitations have on this assessment. For example, to help ensure that students try their best when taking the CCTST, the CCTST test administrators need to emphasize the significance of the CCTST test data with regards to curriculum quality improvement. Also, to maximize the number of matching pre-tests and post-tests, all CCTST test administrators should be more involved with the statistical data so that they can account for missing pre-tests or post-tests. Furthermore, to minimize distractions such as graduation, job hunting, vacation, etc., both the pre-test and the post-test should not be given during the last week of classes. Finally, the test should be administered consistently across all disciplines and should follow pre-established guidelines such as the recommended guidelines listed in the CCTST test manual.

Regardless of the outcome of this study, instructors need to be continually aware of their teaching strategies with regards to enhancing the critical thinking of their students. First, however, instructors need to rethink how students learn by knowing how they think. Once this thinking process is understood, instructors will understand when and why they may need to revamp old methods of teaching in favor of methods that require students to reason, resolve conflicts, examine alternatives, break down arguments, assess credibility, form opinions, and make conclusions. Students will experience more learning when they take charge of their learning and intellectually activate their thinking processes with these new methods; the ability for students to thinking critically will just naturally follow.

# Appendix A: Critical Thinking Cognitive Skills and Sub-skills

The following list represents the consensus list of critical thinking cognitive skills and sub-skills as defined by the panel of experts in The Delphi Report:

| Skill | Sub-skills |
|---|---|
| Interpretation | Categorization |
| | Decoding Significance |
| | Clarifying Meaning |
| Analysis | Examining Ideas |
| | Identifying Arguments |
| | Analyzing Arguments |
| Evaluation | Assessing Claims |
| | Assessing Arguments |
| Inference | Querying Evidence |
| | Conjecturing Alternatives |
| | Drawing Conclusions |
| Explanation | Stating Results |
| | Justifying Procedures |
| | Presenting Arguments |
| Self-Regulation | Self-examination |
| | Self-correction |

(Facione, 1990)

# Appendix B: Affective Dispositions of Critical Thinking

The following list represents the affective dispositions of critical thinking as they relate to the approach taken to life and living in general (Facione, 1990):

1. Inquisitiveness with regard to a wide range of issues.
2. Concern to become and remain generally well informed.
3. Alertness to opportunities to use critical thinking.
4. Trust in the processes of reasoned inquiry.
5. Self-confidence in one's own ability to reason.
6. Open-mindedness regarding divergent worldviews.
7. Flexibility in considering alternatives and opinions
8. Understanding of the opinions of other people.
9. Fair-mindedness in appraising reasoning.
10. Honesty in facing one's own biases, prejudices, stereotypes, egocentric or sociocentric tendencies.
11. Prudence in suspending, making or altering judgments.
12. Willingness to reconsider and revise views where honest reflection suggests that change is warranted.

The following list represents the affective dispositions of critical thinking as they relate to the approach taken to specific issues, questions or problems (Facione, 1990):

1. Clarity in stating the question or concern.
2. Orderliness in working with complexity.
3. Diligence in seeking relevant information.
4. Reasonableness in selecting and applying criteria.

5. Care in focusing attention on the concern at hand.

6. Persistence though difficulties are encountered.

7. Precision to the degree permitted by the subject and the circumstance.

# Appendix C: Common Thinking Styles

The following list defines common thinking styles:

| Style | Key Characteristic |
|---|---|
| Legislative | Being creative.<br>Example: People who like tasks that allow them to do things their own way. |
| Executive | Being conforming.<br>Example: people who like situations in which role they must play or in the way they should participate. |
| Judicial | Being analytical.<br>Example: people who like to evaluate and compare different points of view on issues that interest them. |
| Monarchic | Dealing with one task at a time.<br>Example: people who complete what they are doing before starting something else. |
| Hierarchical | Dealing with multiple prioritized tasks.<br>Example: people who like to first list things that have to be done in a task and then to prioritize the list before undertaking the task. |
| Oligarchic | Dealing with multiple tasks that are not prioritized.<br>Example: people who know what has to be done, but not do not know the correct order the task should be done in. |

Appendix C: Common Thinking Styles (Continued)

| Style | Key Characteristic |
|---|---|
| Anarchic | Dealing with tasks at random.<br>Example: people who let their mind wander and do whatever crosses their mind. |
| Global | Focusing on abstract ideas.<br>Example: people that don't pay much attention to details when making a decision. |
| Local | Focusing on concrete ideas.<br>Example: people that like problems that require engagement with details. |
| Internal | Enjoying working independently.<br>Example: people who like to be alone when working on a problem. |
| External | Enjoying working in groups.<br>Example: people who like to work with others rather than by themselves. |
| Liberal | Using ways to deal with tasks.<br>Example: people who like to do things in new ways. |
| Conservative | Using traditional ways to deal with tasks.<br>Example: people who are not sure their way is the best, so they stick with using known, proven ways of doing tasks. |

(Zhang, 2001)

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