Educational Benefits of Chess Summary Based on Research and Articles

By Dr. Robert Ferguson

Chapter I. The Problem

In modest forms thinking pervades, and to a degree rules, all activities of a human being. Why, then, are we so little concerned with the study of thought processes? –Wolfgang Kohler

Introduction

There is a pressing need, in the opinion of many educators, leaders, employers, and others, to teach young people how to think. Relevant to the assumed need for teaching thinking processes, this book will review two research projects and one pilot study that I designed and directed. These studies propose that critical and creative thinking can be taught using chess as the vehicle. My 1987-88 research also asserts that chess can be utilized to develop memory.

These studies assume that chess can be employed to provide scientific verification for the theories of Dewey concerning human thought. Dewey's theories of reflective thinking have persisted since 1910, but they remain largely absent of scientific validation (McGarry, 1961, p. 3).

Background of the Program

There is a very strong contention among both educators and chess aficionados that chess develops a number of valuable skills. "Chess Makes You Smart" is the upbeat message of the U.S. Chess Federation. Benjamin Franklin promoted a similar idea in his essay *The Morals of Chess*:

> The game of Chess is not merely an idle amusement; several very valuable qualities of the mind, useful in the course of human life, are to be acquired and strengthened by it, so as to become habits ready on all occasions; for life is a kind of Chess, in which we

> have points to gain, and competitors or adversaries to contend with, and in which there is a vast variety of good and ill events, that are, in some degree, the effect of prudence, or the want of it. And this we may learn by playing at Chess (Franklin, 1786).

Franklin went on to list these ***valuable qualities of the mind*** as:

> 1st, Foresight, which looks a little into futurity, and considers the consequences that may attend an action. . . . "If I move this Piece, what will be the advantage or disadvantage of my new situation?" . . .
>
> 2d, Circumspection, which surveys the whole Chessboard, or scene of action. . . .
>
> 3d, Caution, not to make our moves too hastily. . . .
>
> And, lastly, we learn by Chess the habit of not being discouraged by present bad appearances in the state of our affairs; the habit of hoping for a favourable change, and that of persevering in the search of resources. . . .

The first official world champion, Wilhelm Steinitz (1889), expressed the value of chess as follows:

> It is almost universally recognised as a healthy mental exercise, which in its effects on the intellectual faculties is akin to that of physical gymnastics on the conservation and development of bodily strength. Moreover, the cultivation of the game seems also to exercise a direct influence on the physical condition of chessplayers and the prolongation of their lives, for most of the celebrated masters and authors on the game have reached a very old age, and have preserved their mental powers unimpaired in some instances up to their very last moments.

This was the traditional nineteenth century view of the value of chess. In the late 1950's Czech physiologist Dr. Pavel Cerny went a step further by concluding that chess not only helped the mind, but that, according to his research, chessplayers have a higher stamina/strength ratio than nonplayers (Hartston & Wason, 1984, pp. 120-121). Adolf Anderssen claimed that chess was "the gymnasium of the mind." Dr. Peter Wason and International Chessmaster Bill Hartston (1984) believe that chess is more valuable for teaching thinking skills to weak players than for strong ones. They explain:

> At a low level, chess is largely calculation, and might therefore be a useful practice for logical skills. At a high level, it becomes more and more a matter of application of purely chess concepts, and so the practice is of no non-chess use whatsoever. Chess is a better mental exercise for weak players than for strong ones (Hartston & Wason, 1984, p. 59).

Cleveland (1907), in his paper entitled “The Psychology of Chess and Learning to Play It,” identified several dimensions of expertise:

> The mental qualities most utilized in chess playing are: a strong chess memory, power of accurate analysis, quickness of perception, strong constructive imagination and a power of far reaching combination. . . . The most important psychological feature in the learning of chess (and it seems equally true of all learning) is the progressive organization of knowledge, making possible the direction of the player’s attention to the relations of larger and more complex units (p. 305).

Goethe said that chess is the touchstone of the intellect. Gottfried Leibnitz remarked, “I strongly commend the practice of chess and other games of reason, not for themselves, but because they help perfect the art of thinking.” Soviet Minister of Defense, Marshall R.J. Malinovsky, stated:

> We military men value chess highly because it disciplines a man, promotes the development of his will and self-control, develops the memory and quickens the wits, trains a man to think logically; in a word it is, as they say, good mental gymnastics. (Kostyev, p. 15)

Even Presidents Bush and Reagan seem to concur: “Playing chess sharpens the wit, increases foresight, and strengthens one’s ability to solve problems and to interpret the actions of others” (President Bush, 1991). In President Reagan’s July 25, 1985 letter, he wrote “Chess is unique in that it provides pleasure and relaxation, while also stimulating and developing the mind. . . . There are few better ways to strengthen one’s character, improve the thought processes . . . Like all truly classic things, it stands the test of time and will no doubt continue to captivate millions of individuals . . .”

Chess is played between two players, each of whom has 16 pieces that move on a chess board divided into 64 squares in an 8 by 8 array. The players alternate moves, and the goal of the game is to checkmate one's opponent. Said to be the oldest intellectual game in the world, amusing legends are associated with this game, which some authors date back to 3,000 B.C.

The contemporary period is characterized by Soviet domination—chiefly due to government support. Russia alone has more active chessplayers than all the other countries in the world combined. From 1948 to the present, it supplied eight world champions: Botvinnik, Smyslov, Tal, Petrosian, Spassky, Karpov, Kasparov, and current world champion Kramnik.

Many Americans play chess but are not members of the United States Chess Federation (USCF) because they do not compete in USCF rated tournaments. They number more than three million and include many teachers and tens of thousands of youths who play chess in scholastic chess clubs across the country (Dubeck, 1988).

Nonetheless, the game is not nearly so popular in the United States as in some of the 158 (according to FIDE, the International Chess Federation website at www.fide.com/official/directory.asp) other countries that have a national chess federation affiliated with FIDE. For example, the Soviet Chess Federation claimed to have 3,540,000 active players in 1966. "Chess sections exist in every factory or works organization in the country, in every Pioneer Palace, and in almost every college and school" (Sunnucks, 1970). Chess expanded rapidly in the USSR after the government proclaimed chess a cultural and educational factor in 1924 (Kotov & Yudovich, 1958, p. 55). Chess competition increased so quickly that the Trade Union Championship in 1936 had over 700,000 entrants!

In a 1993 Fidelity Electronics' article entitled "The Minds of Tomorrow," the company states, "In light of chess playing's ability to shape future minds, schools all across the United States view chess as a powerful educational tool. Thousands of pre-teens and teens understand that chess coheres the mind to anticipate, make decisions, and react in a way no other game can."

Dr. R.J. Topping (1988), the Coordinator of the Gifted/Talented Programs for the White Plains Public Schools, agrees with Fidelity and states:

> Chess is an integral part of the logic and creative problem-solving segment of our More Able Student curriculum. It cultivates critical thinking skills in our students, enhancing their personal growth and academic learning. We encourage other school systems to consider offering their students experiences in this dynamic content area (Chess in the Schools, 1988, p. 3).

Many teachers use chess as a vehicle to teach critical thinking skills, stressing to students that *how* to think is more important than learning the solution for a specific problem. Through chess, pupils learn how to invent creative solutions to problems. They learn how to analyze a situation by focusing on the important factors. Chess is effective because it is self-motivating. The game is intrinsically fascinating, and the goals of attack and defense, climaxing in checkmate, motivate young people to delve deep into their mental resources (Chess in the Schools, 1988, p. 2).

In my 1986 presentation at the Pennsylvania Association for Gifted Education State Conference, I attempted to answer the question “What is so special about these 32 pieces? Why do they captivate us?”

> I have always loved games, but in Monopoly, every game seems the same. After Boardwalk and Park Place, what is there? In chess after only ten moves, there are 169,518,829,100,544,000,000,000,000,000 possible options! Creativity and variety abound! Every game is a new frontier, an uncharted territory. Chess is a game in which I try to create a problem for my opponent; he in turn solves that problem and tries to pose a more difficult problem for me simultaneously. On my move, I attempt to parry his threat and develop a more challenging problem for him, and on it goes to the end—one problem after another. These problems consume me; hours pass, and yet it seems like only minutes. (Ferguson, 1986)

The studies discussed in this book attempt to understand why chess captivates millions of individuals, and why it seems to make chessplayers better problem solvers.

Statement of the Problem

The major goal of these studies, broadly stated, was to investigate different types of student interest areas that were presumed to help young people develop their problem solving (critical/reflective/analytical thinking) skills. More narrowly, the problem under investigation in these studies is to determine the influence of chess instruction and play upon critical and creative thinking and memory improvement.

Purpose of the Studies

While the primary purpose of the ESEA Title IV-C funded project was to determine what types of activities would help young people develop their problem solving skills, the secondary goal was to create a practical curriculum or training program that could easily be adapted by other schools for teaching thinking skills through the vehicle of chess. The project staff hoped to use student interest areas to motivate participants to increase both their critical thinking and creative thinking skills.

Study II, a short pilot project, attempted to expand the first study by including both gifted and nongifted students and by adding a metacognitive dimension to the study. The purpose was to find out whether students could acquire the basic problem solving methods required for chessplaying and to transfer those processes to "real life" problems.

Study III, a year long experiment in a self-contained sixth grade classroom, was developed to work exclusively with nongifted students to determine whether the transfer of thinking skills noted in the earlier studies with predominantly gifted children could be repeated with nongifted pupils.

As these projects grew and emerged, several products evolved: a student written chess newsletter, a weekly chess column in the local paper written by the students, a variety of chess books authored by the students, numerous tournaments, a chess league, chess seminars, chess camps, simultaneous exhibitions, student-run clubs in the elementary schools, a resident chessmaster, the USA Junior Chess Olympics, and the American Chess School, a nonprofit corporation dedicated to educating the public about this research and implementing chess programs in the schools.

Importance of the Studies

At the 1983 “Conference of the Mind,” partially funded by a grant from the National Science Foundation, one of the speakers summarized the situation as follows:

> Recent research indicates that one of the most neglected areas in today’s educational system is instruction aimed at developing logical reasoning and critical thinking. Reports from various groups (National Assessment of Educational Progress, Commission on Excellence, National Science Board Commission on Precollege Education in Mathematics, Science and Technology, National Council of Teacher’s of Mathematics Recommendations for School Mathematics of the 1980’s, National Council of Supervisors of Mathematics Position Paper on Basic Skills) all suggest that what is lacking . . . is an emphasis on problem solving and the related thinking skills. Unfortunately, these higher level skills are the very ones that are important for success in our emerging technological society. (Heidema, 1983, p. 104)

The use of the best known intellectual game to address the need to improve critical thinking is an innovative approach that has nationwide applicability. Using chess to improve thinking is similar to the heuristic approach to learning which stresses the process of resolving complex or compound problems. Heuristic strategies lie at the heart of the way scientists and engineers approach work daily (Polya, 1957).

Reynolds (1982) writes, “The game of chess has been repeatedly selected as an ***ideal*** task for the investigation of ***problem-solving*** behavior. Chess has the complexity and variety of everyday problem solving . . .” (emphasis added)

Dr. David McArthur (1980) feels that chess cannot only be used to study everyday problem solving but also creative problem solving:

> I believe that chess, as a problem domain, shares some important abstract task features with many real-world problems. . . . by studying intelligent problem solving in chess, one can shed light on intelligent problem solving in domains that share its task features. . . . I feel that by studying chess one is in a particularly good position to learn about important human problem solving skills or competencies that have gone unnoticed in the recent literature. . . . it seems to be a hallmark of more "creative" problem solving . . . (pp. 12-13)

My studies have significance for all schools desiring to train young people for the future. Employers throughout the United States have expressed the need to teach students how to think better. Educators continue to endorse the importance of teaching reflective thought processes. One example of this is the National Education Association (Educational Policies Commission) publication in 1961. The importance of teaching reflective thinking was recognized in this statement.

> The purpose which runs through and strengthens all other educational purposes—the common thread of education is the development of the ability to think. This is a central purpose to which the school must be oriented if it is to accomplish either its traditional tasks or those newly accentuated by changes in the world. To say that it is central is not to say that it is the sole purpose or in all circumstances the most important purpose, but it must be a pervasive concern in the work of the school. Many agencies contribute to achieving educational objectives, but this particular objective will not be generally attained unless the school focuses on it. In this context, therefore, the development of every student's rational powers must be recognized as centrally important. (p. 12)

Dr. Gerard Dullea, former Executive Director of the United States Chess Federation, suggested in his November 1982 *Chess Life* article that chess is a valuable classroom tool. He hypothesizes that chess makes kids smarter (Dullea, 1982, p. 16) by providing "an intellectually stimulating, rewarding activity, but it can also teach discipline, concentration, planning and all the other good things that go into successful chess." Dullea hastened to add that there was a need for additional research.

In addition to the above arguments, it seems reasonable that introducing youngsters to a game that is a ***cultural and classical institution*** is, in its own right, a worthwhile educational goal. Consider music, which is a required course in most schools. The question of whether it serves some other purpose apart from learning about music is rarely posed (de Groot, 1977). **Music** and **chess** are two of the most common sources of child prodigies, and yet only music receives accepted status in most curricula.

Another reason this study is both important and meaningful is that we are in the midst of the computer age and are overwhelmed with an abundance of data. The former American Federation of Teachers' president, Albert Shanker (1985), addressed this information overload as follows:

> The amount and nature of the information, misinformation, and disinformation that constantly bombard us, coupled with the continuous demand for new skills in an increasingly technological age, suggest that never before have skills in rational thought and reasoned judgment been so urgently needed (p. 21).

With the information explosion, there will be continuing challenges for our schools: to interpret and cohere this quantity of information, to instruct students in the skills they need to solve complicated social and political problems, and ***to teach students precise thinking skills***, i.e. analytical/critical/ reflective thinking. America's future is dependent upon the ability of teachers and schools to develop students who are able to think. CEOs and managers are demanding workers who can think for themselves. With the increasing information overload, it is incumbent upon our schools to teach students how to prioritize the aspects of a problem in order to determine the best solution. Perhaps chess, which requires its competitors to focus on the most critical data on the chessboard for solving problems, can serve as a tool to answer this dilemma.

Questions to be Answered

As we have noted in both the background section and the importance of studies section, the mental qualities most utilized in chess playing are: ***memory***, power of accurate ***analysis***, quickness of ***perception***, ***imagination*** and a power of ***combination***. This elicits an obvious question: Can chess develop these qualities?

Although earlier research determined that chess could accelerate intellectual maturation, I could find no statistically based studies verifying the assumptions of the chessmasters or authors that chess improves critical or creative thinking; therefore, the two qualities selected for investigation in Study I, the ESEA project, were analysis (or analytical/critical/reflective thinking skills) and imagination (or creative thinking skills).

Questions on Critical Thinking

1. Can chess—as the chessmasters assume—enhance critical thinking skills?
2. Can a chess course enhance critical thinking more than a computer problem solving course; will they prove equally effective; or will the computer course demonstrate superiority?
3. Will the nonchess treatment group surpass the chess group?
4. How will gifted students who do not participate in the reflective thinking development project compare to those who do?

Questions on Creative Thinking

1. Can chess—as some masters assume—enhance creative thinking skills?
2. Can a chess course enhance creativity more than a computer problem solving course; will they prove equally effective; or will problem solving with the computer test superior?
3. Will the nonchess treatment group surpass the chess group?
4. Will chess improve certain aspects of creativity more than computer problem solving?
5. Which types of creative thinking will be increased more by computer problem solving and which will be better enhanced by chess problem solving?

6. How will students who do not participate in the thinking development project compare to those who do?

Questions One Year into Project

After the results of the first year (79-80) of the Title IV-C project, I decided to do additional research. Several questions emerged after the first year of testing**:**

1. Why were the scores by the chess group so much higher than those of any other group?
2. Were the high increases registered by the chess group a coincidence?
3. What influence does learning chess have on critical thinking?
4. What influence does learning chess have on creative thinking?

Questions for Study II

The primary questions for my 1986 pilot study included the following:

1. How do students think when trying to solve a problem?
2. Can students increase thinking accuracy by using a system?
3. Should students be encouraged to combine systems of different modalities or should students rely on the systems that are most similar to their individual thinking systems/learning styles?
4. Can students generate a variety of thinking systems?
5. How does a student innately go about improving his/her system for thinking?
6. How does an individual's personality affect his/her thinking style?

Thinking skills are of increasing concern to educators. David Perkins, former co-director of Project Zero at Harvard University, states, "We've wanted children to learn how to think, and we've assumed that conventional education speaks to this, but research suggests that students' levels of critical thinking are quite low" (Wernick, 1987). Perkins went on to state that ". . . Ferguson would not have obtained the same results with nongifted students. Bright kids are able to transfer skills from one activity to another without being taught to do so. . . . The average student would need explicit instruction to identify problem-solving principles and learn how to apply them to other areas." I countered Perkins' claim by querying, "Why is it, Dr. Perkins, that none of the other choices specifically selected to develop thinking skills among the gifted population demonstrated any significant gains?" Nevertheless, I took Perkins claims seriously and responded by developing another study using only nongifted students and combining the strategies used in Study I and Study II.

Questions for Study III

During Study III, the 1987-88 research project, I focused on fewer variables. The questions for this study included:

1. Will chess instruction and play enhance memory?
2. Will chess instruction and play enhance verbal reasoning?
3. Will students who are ***required*** to take chess lessons enjoy it?

Statement of Hypotheses

In Study I, the ESEA Title IV-C project, the initial hypotheses were based on the above questions and the gifted program's goal of providing challenging enrichment experiences based on student interest areas. These options were selected by a task force (comprised of GT teachers, parents, and students) on gifted education after analyzing dozens of activities believed to foster critical and creative thinking skills.

<u>Hypothesis one</u>: There will be greater progress demonstrated on a critical thinking test by gifted students participating in the thinking skills development program as compared to nonparticipating gifted students.

Hypothesis two: There will be greater progress demonstrated on a test of creativity taken by students identified as gifted, who participate in the thinking skills development program, than those who do not participate.

In my 1986 pilot study designed as a critical thinking program under the auspices of the Tri-State Area School Study Council, the hypothesis favored the chess group over the group taking SAT preparation.

Hypothesis: The chess group will demonstrate higher growth than the SAT group as measured by increased performance by the chess group in tournament play compared to the SAT group's performance on the SAT tests and practice tests.

In the 1987-88 experiment using sixth graders, the project supervisor hypothesized that the chess group would demonstrate significant growth in both verbal reasoning and memory.

Hypothesis one: There will be a significant difference in scores on a memory test from the beginning of the year to the end of the school year for students who participate in the chess program.

Hypothesis two: There will be a significant difference in scores on a verbal reasoning test from the beginning of the year to the end of the school year for students who participate in the chess program.

Postulates

The organizers of the ESEA Title IV-C project selected a variety of student interest areas that they assumed would aid in the development of critical and creative thought. I, as project director, postulated that students would be motivated to participate because they had been allowed the opportunity to generate a list of activities and then choose from those options. I further held that the project time span for the ESEA funded project was sufficient to permit differences to be seen.

In the 1986 pilot study, I served as the program coordinator and assumed that the individuals comprising the chess group would be familiar with their modality strengths and preferred learning styles. I thought students of all levels would benefit to some degree from the experiment.

The 1987-88 experiment presumed that students who were required to study and play chess would still be enthusiastic about the game. I felt that the nongifted students could potentially benefit even more from the chess instruction than their gifted peers. I assumed that reasoning skills as measured by the *Test of Cognitive Skills* would be comparable to the critical thinking skills evaluated by the *Watson-Glaser Critical Thinking Appraisal* and would be more age appropriate.

Delineation of the Research Problem

In these studies, the dependent variables included scores on a critical thinking test, a creative thinking test, a verbal reasoning test, and a memory test; the most prominent independent variable was chess (instruction and competition combined).

In Study I (1979-83), the gains on two standardized thinking tests (*Watson-Glaser Critical Thinking Appraisal* and the *Torrance Tests of Creative Thinking*) were measured. The following variables were compared with the dependent variables to determine which ones have the greatest relationships: sex, grade, computer study, chess study, and nonchess study. The gains of the chess group were compared to the gains of the computer group and the nonchess group. Differences between male and female gains in means on the standardized tests were noted. Grade level gains were compared and analyzed as well.

The following items were excluded from the control variable list: absenteeism, behavior, academic achievement, birth order, and age. All of the students in the study were gifted (IQ above 130); most were motivated to participate and rarely absent. After a cursory review of student ages, I determined that a comparison of age against gains on the standardized tests would be largely a duplication of the grade level gains analysis. Because groups were formed by self-selection, it was impossible to control for sex and grade differences. To compensate, I evaluated male growth and female growth both separately and within their groups. Analysis was also made by grade level to determine levels of difference.

Study II (1986 pilot study) compared chess students performance rating at the Pennsylvania State Championship to their official rating to determine growth in thinking skills. The SAT group compared pretest scores to posttest scores on computerized SAT practice tests to evaluate gain in thinking skills.

During Study III (1987-88), all students in a sixth grade self-contained classroom were required to participate in chess lessons and play games. This experiment was more intense because students played chess daily over the course of the project. The dependent variables were the *Test of Cognitive Skills* Memory subtest and the Verbal Reasoning subtest from the *California Achievement Tests* battery. Gains on the tests were compared to national norms as well as within the treatment group. Differences between males and females on the tests were also statistically analyzed.

Scope and Delimitations of the Studies

The scope of these studies varies. **Study I**, the ESEA Title IV-C federally funded research project, was approved for three years (six semesters). It was extended for one school year at local expense for a combined total of four years; however, in actuality it was ***not*** a four-year study, it was ***four one-year studies***. The Title IV-C project was an investigation of students identified as mentally gifted with an IQ of 130 or above. Students in the nonchess groups exceeded those in the chess group in Mean IQ by 2.3 points, which is not significantly different. All participants were students in the Bradford Area School District in grades 7 through 9. Individuals sampled in this study could not be randomly assigned to groups because the students' individualized education plans prescribed activities based on interests. Independent variables included chess instruction and play, problem solving with computers, Olympics of the Mind, Future Problem Solving, creative writing, Dungeons & Dragons, independent study, and small group investigations. The primary independent variables reviewed in this book will be the chess treatment, the computer treatment, and all nonchess treatments combined. Some treatments had only one, two, or three students involved which makes statistical testing impractical; therefore, the treatments were combined and labeled 'nonchess' group or treatment. Each group met once a week for 32 weeks in the gifted resource room at Bradford Area High School to pursue its interest area under the leadership of the Coordinator of Secondary Gifted Education (Robert Ferguson). Most groups spent a total of 60-64 hours pursuing their preferred activity. The dependent variables were the differences in the means of the posttests from the pretests. Data was collected from the *Watson-Glaser Critical Thinking Appraisal* and the *Torrance Tests of Creative Thinking*. The chi-square test and the t test were applied to determine the level of statistical significance.

The 1986 pilot study (**Study II**) focused on only two independent variables: chess and SAT preparation. Students in the chess group met once a week for eight weeks in the resource room for the gifted at Bradford Area High School for lessons and practice. Total time for the chess group was 16 hours. Students in the SAT group spent from seven to twenty hours (Time was dependent upon individual schedules and the availability of the one computer in the resource room.) using the SAT software. Analyses were based on the performance of the chessplayers in tournaments and computerized SAT practice tests (CBS software *Mastering the SAT*) for the SAT group.

During the 1987-88 investigation (**Study III**), all students in a sixth grade self-contained classroom at M.J. Ryan School (*The M.J. Ryan School, with a student enrollment of 116 in grades K-6, is a rural school about 18 miles from Bradford*.) were required to participate in chess lessons and play games. None of the pupils had previously played chess. This experiment was more intense because students played chess daily over the course of the project, which ran from September 21, 1987 to May 31, 1988. The dependent variables were the data on the *Test of Cognitive Skills* Memory subtest and the Verbal Reasoning subtest from the *California Achievement Tests* battery, and the differences from the pre and posttests were measured statistically using the t test of significance.

Definition of Terms

In order to better understand the various terms that are frequently used in this study, a number of definitions are provided below. For some terms, both operational definitions and definitions from the literature are given.

Analytical Thinking. The Pennsylvania Department of Education (1985) stated that there are three key skills in analytical thinking, namely: *making inferences,* which relates to the ability to distinguish valid idea from invalid ones; *information processing*, which involves predicting consequences of various courses of action and comparing possible decision choices; and *drawing conclusions*, which requires one to consider all available information when deciding what solution to choose.

Chessplayer. I established for the purpose of these studies that the term chessplayer refers specifically to the chess students participating in the experiments. There were other students who knew how to play chess that did not elect the chess program of study.

Creative Thinking. Torrance (1974) defined creative thinking as "a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies: testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results."

Critical Thinking. Watson and Glaser (1964) defined critical thinking as: "(1) attitudes of inquiry that involve an ability to recognize the existence of problems and an acceptance of the general need for evidence in support of what is asserted to be true; (2) knowledge of the nature of valid inferences, abstractions, and generalizations in which the weight or accuracy of different kinds of evidence are logically determined; and (3) skills in employing and applying the above attitudes and knowledge" (p. 10). Skinner (1976) lists the process components found in the literature frequently associated with critical thinking as "the ability to recognize a problem, formulate an hypothesis, gather data, analyze data, reject or accept the hypothesis, and draw conclusions" (p. 22). The literature uses the terms reflective thinking and critical thinking synonymously (Dull, 1964). In the studies discussed in this document, the researcher will use the terms reflective thinking and critical thinking synonymously.

Eclectic Thinking. Lasker (1947) defined this method of thinking in chess as a harmonic union of both the positional thinker and the tactical thinker. Krogius uses the term "universal" to describe the eclectic thinker (Krogius, 1972, p. 13).

Flexibility. Torrance (1974) established that verbal flexibility represents a person's ability to produce a variety of types of ideas, to shift from one approach to another, or to use a variety of strategies.

Fluency. Torrance (1974) defined verbal fluency as an individual's ability to generate a large number of ideas with words.

Metacognition. Bonds (1992) defined metacognition as the knowledge and awareness of an individual's own cognitive processes and the ability to regulate, evaluate, and monitor one's thinking, which affords more efficient and dynamic learning.

Nonchessplayer. I identified the nonchessplayer in these studies as meaning any student who did not participate in the chess component of the experiments.

Originality. Torrance (1974) described verbal originality as the ability to produce ideas that are different from the obvious, commonplace, banal, or established.

Positional Thinking. Lasker (1947) portrayed the positional thinker as one who has the general plan to build a strong and familiar position. In the opening of the game, the positional thinker avoids violent moves, aims for small advantages, accumulates them, and, after attaining these, searches for a solid attack. The positional player tends to be more defensive. He conceives chess as a scientific discipline with definite guiding principles.

Problem Solving. Dull (1964) established that this method of thinking involves searching to find satisfactory solutions to perplexing situations, usually requiring considerable thought or skill. In solving chess problems, thinking is required of the player when he evaluates the position to find what he considers to be the best move. The literature also uses the terms problem solving, reflective thinking, and critical thinking synonymously (Dull, 1964).

Reflective Thinking. Dewey (1933) defined reflective thinking as the process of transforming a perplexing situation (state of doubt) into a coherent judgment or conclusion. To Dewey the function of reflective thought is to change a problematic situation (indeterminate) into a determinate situation or solution. Reflective thought is the behavior exhibited by a person when they meet a situation they cannot deal with on the basis of habit. Dewey used the following example (1933) to illustrate the problematic situation:

> A man traveling in an unfamiliar region comes to a branching of the road. Having no sure knowledge to fall back upon, he is brought to a standstill of hesitation and suspense. Which road is right? And how shall his perplexity be resolved? There are but two alternatives: he must either blindly arbitrarily take his course, trusting to luck for the outcome, or he must discover grounds for the conclusion that a given road is right. (p. 13)

In these studies, reflective thinking is operationally defined as the method of thinking characterized by the chessplayer when he or she analyzes a chess position in order to determine the best or most accurate move. The chess position provides the perplexing situation, and the selected move provides the final judgment or solution.

Tactical Thinking. Lasker (1947) wrote that in chess the tactical thinker is a combinational thinker, combining the force of his chessmen (pieces) to create advantages; he is an adventurer, who feels comfortable being the aggressor. This type of thinker thinks forward; he or she starts from a given position and tries to find the forceful moves. The tactical thinker's conceptual ability is especially evident in the middle segment of the game, when the pieces create a great variety of possible moves. Tactical thinkers are reflective thinkers. The chess position creates the problem, the selection of move creates the observational mode of thought, and the chosen move is the solution. Tactical thinkers have highly developed powers of creative imagination and the ability of far reaching concrete calculation.

Summary and What is to Follow

The rebirth of the chess problem as a tool for studying complex human thinking has two main causes: 1) the chess game is the type of problem that pushes human cognitive capacity to its limits and 2) the game of chess is well defined in the objects (chess pieces), and the primitive operations (the moves) are known (Chase & Simon, 1973).

In *Search for Excellence*, Peters and Waterman (1982) cite the classic chess studies to show that the manager who thoroughly comprehends his or her organization will be better able to process data efficiently and thereby make superior decisions. It is obvious from these references and numerous others that chess is an accepted tool for studying problem solving.

The guiding assumption of the 1979-83 research study is that chess can be used as a vehicle to scientifically test the theories of John Dewey concerning reflective thinking. This study also investigated creative thought.

My 1986 pilot study focused on requiring students to identify their thought processes when solving problems, to verbalize their thinking systems, to write their individual systems, and to experiment with their systems by solving a variety of problems, including "real life" problems.

The 1987-88 research study, which was conducted in a self-contained sixth grade classroom, was specifically designed to test whether chess instruction and competition could be used to increase reasoning and memory skills for average students at the sixth grade level.

Chapter one has introduced the problem, the purpose of the research, the importance of the study, and provided some of the current thinking on chess in education. The following chapter will present a review of related literature. The third chapter will offer methodology, including research design, tests, classroom procedures, course objectives, lesson plans, curricula, data collection, and limitations. In chapter four, I will submit the findings and interpret them. Finally, in the fifth chapter, I will briefly review the Bradford Area School District chess studies, share conclusions, and make recommendations.

Chapter II. Review of Related Literature

Intellectual affection is the only lasting love. Love that has a game of chess in it can checkmate any man and solve any problem of life. –Charles Dickens

Organization of Chapter II

I. Lists the sources searched.

II. Offers general background information along with a discussion of historical and philosophical development of reflective thinking.

III. Presents research related to my studies.

IV. Reviews literature on the formal instruments used in these studies.

V. Summarizes chapter and offers a cursory glance at this book's intent.

Sources Searched

A literature search using the Educational Resources Information Center, Resources in Education, the Thesaurus of ERIC Descriptors, the Current Index to Journals in Education, and Dissertation Abstracts reveals that no dissertation related specifically to my studies has been completed. One of the literature sources used (ERIC computer search) reviewed the literature in chess from 1890 to the present. Other sources used to review the literature were the *Index to American Doctoral Dissertations in Progress, Dissertation Abstracts* by American Universities, *Microfilm Abstracts of Doctoral Dissertations*. Six dissertations dealing with chess were reviewed: "An Experiment to Alter 'Achievement Motivation' in Low-Achieving Male Adolescents by Teaching the Game of Chess" by Harry Turner, "Chess and Cognitive Development" by Johan Christiaen, "Chess and Aptitudes" by Albert Frank, "Chess Strategies: A Course of Study Designed as an Introduction to Chess Thinking" by Stephen

Schiff, “Playing Chess: A Study of Problem-Solving Skills in Students with Average and Above Average Intelligence” by Philip Rifner, and “Intelligent Problem Solving in Chess” by David John McArthur.

Further sources, including *Cognitive Psychology, Experimental Psychology,* and other journals, provided more than one hundred current investigations in the area of problem solving in chess.

In addition, it was fundamental to the studies of reflective or critical thinking to gain a comprehensive understanding of what defines “reflective” thinking. John Dewey’s book, *How We Think* (1933), provided a great deal of information toward this end.

There are several manuscripts related to chess theory that are worth reviewing. In the volume *Think Like a Grandmaster*, by Kotov, the complex thinking that takes place in a grandmaster’s mind is described. Euwe’s book, *Judgment and Planning in Chess*, demonstrates the way to improvement by showing the reader how to think, how to judge a position, and how to make a plan. In *Chess Psychology*, by Nikolai Krogius, various thinking methods in chess were discussed. Dr. Emmanuel Lasker presented a lucid description of the three basic methods of chess thinking in Lasker’s *Manual of Chess*. Pfleger and Treppner’s *Chess The Mechanics of the Mind* pinpoints key situations where the amateur’s thought processes are inferior and seeks to help him overcome specific mental barriers. *The Psychology of Chess* by Hartston and Wason explore essential thought patterns of masters. In *How Chessmasters Think*, Paul Schmidt demonstrates the thought processes a chessmaster uses to analyze the strengths and weaknesses in a position and how he decides upon a course of action. Chernev and Reinfeld’s book, *Winning Chess*, is a hands-on, learn-by-doing book that teaches tactical thinking skills.

General Background Information

Reflective Thinking

Historically, reflective thinking can be traced to John Dewey. According to Kitchener (1983):

> The individual most closely associated with the historical antecedents of reflective thinking and its importance for education was John Dewey. He not only initiated the discussion of reflective thinking, he also provided the initial theoretical arguments for it. To some extent he is also responsible for the proliferation of terms which are partially synonymous with it since he variously referred to reflective thinking as being or as including critical thinking, problem solving, inquiry, and reflective judgment. (p. 76)

Philosophically, reflective thinking can be traced to a movement called pragmatic naturalism. William James, Charles Peirce, George Mead, and John Dewey pioneered this movement in America. By definition, pragmatic naturalism is a problem solving method of thinking where experiential problems (perplexing situations) are transformed into solutions (Eames, 1977). Eames used the term "pragmatic naturalism" rather than the term pragmatism because the meaning of the term pragmatism is often misinterpreted to mean "practical," in a vulgar sense (Eames, 1977).

Since Dewey lived the longest of the pioneers of pragmatic naturalism, wrote the most, and engaged in more intellectual controversies, he contributed prodigiously to theories about this method of thinking. In his work *Essays in Experimental Logic*, Dewey stated, "I . . . affirm that the term 'pragmatic' means only the rule of referring all thinking, all reflective considerations, to consequences for final meaning and test" (Winn, 1959, p. 105). Out of Dewey's philosophical position of pragmatism evolved reflective thinking considerations.

Although reflective thinking owes its inception to Dewey, approximations of it can be found in earlier thinkers including (according to Peirce and James) Socrates and Aristotle (Runes, et al, 1962, p. 245). Furthermore, the Baconian system of thought is also founded on empirical observation, analysis of observed data, inference resulting in hypotheses, and verification of observed hypotheses through continued observation and experiment (Runes, 1962, p. 34).

No American has contributed more to the theories of pragmatic naturalism and reflective thinking than Dewey. He not only initiated the discussion for reflective thinking, he also provided the initial theoretical arguments for it (Kitchener, 1983, p. 75). Dewey wrote and published books on reflective thinking as early as 1910. In his book, *How We Think* (first published in 1910), he provided the structural and theoretical constructs of reflective thinking. Dewey persistently argued that the basic **aim of education must be to teach reflective thinking.** He also argued that reflective thinking was a better way to reason concerning problems than unfounded belief in authority or belief that rests with emotional commitment. Dewey maintained that reflective thought was more correct than alternatives based on either authority or emotional commitment because they are not derived from careful collection and evaluation of evidence; they don't require verification. Dewey states:

> Active, persistent, and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it and further conclusion to which it tends constitutes reflective thought. (Dewey, 1910)

Dewey called an awareness of a problem the pre-reflective stage. It is the uncertainty that initiates inquiry; if there is no doubt, reflective thinking is not called for. The bottom line in reflective thinking is judgment which identifies a solution for the problem.

> Dewey refers to judgment as a "grounded assertion" or a "warranted assertion" which suggests it must be substantiated by valid reasoning about sources of information (i.e., data events), which exist outside of the thinker himself or herself. Ultimately the validity of judgments must be evaluated in terms of their outcome. (Kitchener, 1983, p. 77)

In his book, *The Quest for Certainty,* Dewey (1930) asserts the end process of inquiry is knowledge. He argued that "inquiry leads to truth." A solution based on reflective thinking is more likely to be accurate than those based on narrow reasoning or from authority.

By definition, critical thinking and reflective thinking mean essentially the same thing. Kitchener asserted (1983) that attempts to measure educational outcomes of reflective thinking usually derive from the empirical research tradition known as critical thinking (p. 78). S.B. Skinner (1976) stated, "A review of the literature reveals that such concepts as scientific method, scientific thinking, reflective thinking, productive thinking, and critical thinking have within a small tolerance the same meaning" (p. 293). In the book, *Teaching Critical Thinking in the Secondary School,* the Ohio Association of Supervision and Curriculum Development Commission used the terms critical thinking and reflective thinking synonymously.

Critical thinking, according to Robert Ennis (1981), ". . . is reasonable, reflective thinking that is focused on deciding what to believe or do."

Structurally, critical thinking and reflective thinking are the same. In process, they both are problem solving methods of thinking that are derived from the scientific method. The only difference between them appears to be that reflective thinking is a more extensive concept. Dewey referred to reflective thinking as being or including critical thinking, problem solving, inquiry, and reflective judgment (Dewey, 1938). Between the pre-reflective stage and judgment, lies the process called critical inquiry (Dewey, 1938). Dewey suggests that critical inquiry includes five elements:

1. Awareness of a perplexity, a problem occurring in a primary or immediate experience.
2. Location and definition of the problem are made concerning

what kind of problem is present.

3. Entertainment of suggested hypotheses or ideas for the solution of the problem. Several hypotheses may be considered.
4. Reasoning out the consequences of each hypothesis.
5. Finally, the selected hypothesis for the solution of the problem is tested in direct action.

After a review of the literature, the same five steps are found in the critical thinking process:

1. Recognizing and defining a problem.
2. Clarifying the problem.
3. Formulating possible explanations or solutions.
4. Selecting the most promising hypothesis (after testing).
5. Stating tentative conclusion. (Dressel, 1976, p. 293)

The *Watson-Glaser Manual* offers a very similar list of critical thinking abilities on page 10:

1. The ability to define a problem.
2. The ability to select pertinent information for the solution of a problem.
3. The ability to recognize stated and unstated assumptions.
4. The ability to formulate and select relevant and promising hypotheses.
5. The ability to draw conclusions validly and to judge the validity of inferences.

Creativity

Robert J. Eaton, former CEO of Chrysler, states, ". . . we know that our future depends on the creativity of our people. We are also convinced that creativity must be nurtured in our young people if we are to continue to be leaders in the global economy." (Eaton, 1993) How can we effectively nurture creativity in children?

Noting that chess may be mastered at a very young age, George Steiner (1973) pointed to two other fields in which creative results have been achieved before the age of puberty—music and mathematics. Only in chess, music, and mathematics have profound, original insights been contributed by preadolescents.

What is creativity? What is originality? Some of the major theories of creativity discussed in Gowan's *Development of the Creative Individual* (1972) include:

1. Psychedelic: Stresses the mystical, non-ordinary experience of reality and altered states of consciousness (natural or drug induced) as stimuli for creativity à la Timothy O'Leary.
2. Mental Health: Emphasizes growth, self-realization, or self-actualization and the dynamic effort of people to fulfill themselves.
3. Freudian/neo-Freudian: Accents the conflict of the conscious, reality-bound thinking and experience with more open, spontaneous preconscious or unconscious experiences.
4. Personality/environmental: Stresses the personality traits or characteristics of highly creative persons, emphasizing the nature of the person's make-up or general patterns of responding to experiences and to social pressures.
5. Cognitive, rational, semantic: Emphasizes creativity as a systematic, deliberate process of generating novel ideas or solutions, stressing creative thinking, problem solving, or associations.

Obviously creativity is a very broad and complex subject, and there is substantial disagreement about its true nature. Some (Kreuter & Kreuter, 1964;

Mueller, 1964) believe that the term "creative" should be exclusively reserved for fields like art, music, and writing.

Torrance's communication (1974) with authors and creative artists about what happens when they are involved in the creative process and how they guide the creative learning of their students confirms that Torrance's definition of creativity fits the creative artists' concept as well as it does that of the creative scientists. Both Torrance (1974) and Guilford (1967) stress four component parts of creativity: fluency, flexibility, originality, and elaboration.

Fluency—verbal fluency—reflects an individual's ability to generate a large number of ideas with words. Verbal flexibility represents a person's ability to produce a variety of types of ideas, to shift from one approach to another, or to use a variety of strategies. Verbal originality stands for the individual's skill at producing ideas that are different from the obvious, commonplace, banal, or established. Torrance states, "The person who achieves a high score on verbal originality usually has available a great deal of intellectual energy and may be perceived as rather nonconforming. He or she is able to make big leaps or 'cut corners' in obtaining solutions" (1974, p. 57). Verbal elaboration relates to school achievement—especially grades from teachers. These types tend to be inventive and take constructive action. Individuals scoring low in verbal elaboration tend to be underachievers, delinquents, or school dropouts.

Newell, Shaw, and Simon (1962) state that problem solving may be considered creative if one or more of the following conditions are met:

1. The product of the thinking has novelty and value (either for the thinker or for the culture).
2. The thinking is unconventional, in a sense that it requires modification or rejection of previously accepted ideas.
3. The thinking requires high motivation and persistence, taking place either over a considerable span of time (continuously or intermittently) or at a

high intensity.
4. The problem as initially posed was vague and undefined, so that part of the task was to formulate the problem from itself.

Torrance stresses that creativity is a *process*. In comparing Torrance's definition of creativity with Dewey's definition of reflective thinking, it is obvious that there are many similarities.

1. Torrance's first step in the creative process is "becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on. . . ." Dewey's "awareness of a perplexity" is very similar.

2. The second step is "identifying the difficulty." Dewey discusses ". . . what kind of problem is present."

3. Torrance's third step in creative growth is "searching for solutions, making guesses, or formulating hypotheses about the deficiencies . . ." Dewey refers to ". . . suggested hypotheses or ideas for the solution of the problem."

4. In the fourth step, Torrance mentions "testing and retesting these hypotheses and possibly modifying and retesting them. . . ." There is a slight divergence here. Torrance's definition seems to create an image of a scientist in a laboratory trying experiment after experiment, where Dewey speaks of "reasoning out the consequences of each hypothesis."

5. Finally, Torrance states it is necessary to communicate the results. Dewey indicates that the fifth step is to test the hypothesis.

Torrance's definition is based upon his observation and research of high level creative persons. It describes the natural human process. There appears to be very little difference in the processes among critical thinking, reflective thinking, and creative problem solving. The major differences appear to be in the way Torrance measures the method by simulating the creative process within the tests. Since creative thinking is what leads to the advancement of society, it seems reasonable to conclude that schools should encourage originality, fluency, and flexibility.

There are other issues that need to be investigated also. “Verbal processing in chess is another area requiring attention,” according to Holding (p. 235). Chessplayers often verbalize in their minds when studying chess problems. Especially, auditory learners formulate goals in verbal terms and consider candidate moves by subvocalizing.

Memory

Extensive research has been done on both short term memory (STM) and long term memory (LTM). Investigation has confirmed that strong chessplayers are better able than weaker players to recall briefly exposed board positions (Holding, 1985). The variance in memory between stronger and weaker players appears to rely on the number of comparatively specific patterns they can identify on the chess board. It is, of course, logical to assume that an expert because of his vast storehouse of information would appear to have greater memory than a novice, but can chess enhance memory in other areas?

I was able to find no statistical analysis to support this concept, although several authors believed that chess could help develop memory skills for other areas. Holding (1985) questions, “What does this experience include? It seems unlikely that the master’s store of chess knowledge is limited to generic memory, or that his specific memory is limited to chunking . . . There is almost no experimental information . . .” (Holding, 1985, p. 230)

It is certainly credible to suggest that chess could help develop memory. An individual studying a given chess position may look three moves deep at a certain alternative move (potential solution to problem); he may then consider nine more alternatives before deciding on the best solution. This short term memory would be required to visualize and remember 10 x 6 bits of information at the minimum. For each alternative, there are new sets of problems creating more options to remember. As an individual goes through this process for several hours a week, it is not inconceivable that generic memory skills could be enhanced through exercising the brain.

Related Research

This section reviews the literature on research relevant to my investigations, teaching reflective/critical thinking skills, the relationship between chess and reflective thinking, the effects chess has on creative thinking, memory, and verbal reasoning (including reading). Because problem solving, critical thinking, and logical thinking are also tied to mathematics, I decided to include the chess studies demonstrating improvement in math skills. Additional research demonstrates that there is a significant relationship between self-concept and academic achievement (Brookover, Thomas, and Patterson, 1985), as well as standardized tests (Covington, 1989); therefore, I decided to include the chess studies attempting to foster improved self-concept.

Relationship Between Chess and Math

In a 1977-78 study (Nurse, 1995) at the Chinese University in Hong Kong by Yee Wang Fung, chessplayers showed a 15% improvement in math and science test scores. This study was noted at the 1995 “Chess in Education: A Wise Move” Conference but was not available, presumably because it had not translated. Results showed (Langen, 1995) statistically significant improvement in math and science scores after just one year of chess exposure.

“Etude Comparative sur les Apprentissages en Mathématiques 5e Année” by Louise Gaudreau (30 June 1992) has recently been translated and offers some of the most exciting news yet about chess in education. The study took place in the province of New Brunswick from July 1989 through June of 1992.

Three groups totaling 437 fifth graders were tested in this research. The control group (Group A) received the traditional math course throughout the study. Group B received a traditional math curriculum in first grade and thereafter an enriched program with chess and problem solving instruction. The third group (Group C) received the chess enriched math curriculum beginning in the first grade.

There were no significant differences among the groups as far as basic calculations on the standardized test; however, there were statistically significant differences for Group B and C in the problem solving portion of the test (***21.46%*** *difference in favor of Group C over the Control Group*) and on the comprehension section (***12.02%*** *difference in favor of Group C over the Control Group*). In addition, Group C's problem solving scores increased from an average 62% to 81.2%! Not only is this statistically significant, but also the addition of chess to the math curriculum has rendered scholastic chess wildly popular in New Brunswick.

With the inclusion of chess in math, a provincial grade school chess championship was established. In 1989, 120 pupils participated. By 1992, 19,290—***yes, 19,290!!***—pupils competed.

Michel Lyons, the author of the math textbook integrating chess into the curriculum, is a mathematician and not a chessplayer. He felt that the success noted by inclusion of chess lay in its ability to exemplify and manifest the heuristic learning principle. Lyons commented that chess is unique in this respect because it is a well-defined game, and children like games (Langen, 1995).

In December 1996, Arman Tajarobi wrote, "For the past three years, I've been a witness to an experiment held in 24 elementary schools in my town. The school board allowed these schools to replace an hour of math classes by a chess course each week for half of their students. For three consecutive years, the groups receiving the chess formation have had better results in maths than those who did not. This year (the fourth year), the school board has allowed any school that wants to provide its students with a chess formation to do so." (NAESP's Principal OnLine Forum Archive)

Another research project demonstrating the impact of chess upon math was coordinated by James Liptrap in Texas. In his 1994-97 study (Liptrap, 1998), regular (non-honors) elementary students who participated in a school chess club showed twice the improvement of non-chessplayers in Reading and Mathematics between third and fifth grades on the Texas Assessment of Academic Skills.

In fifth grade, regular-track chessplayers scored 4.3 TLI points higher in reading ($p < .01$) and 6.4 points higher in math ($p < .00001$) than non-chessplayers. The purpose of this study was to document the effect of participation in a chess club upon the standardized test scores of elementary school students. The study was conducted in four of the elementary schools in a large suburban school district near Houston, Texas. It compared the third grade and fifth grade scores on the Texas Assessment of Academic Skills (TAAS) of students who participated in a school chess club in fourth and/or fifth grade with the scores of students who did not participate in a chess club. Significant improvement in math and reading scores were found among the regular track chess students.

Reports from students, teachers, and parents not only extol the academic benefits of chess on math problem solving skills and reading comprehension, but also report increased self-confidence, patience, memory, logic, critical thinking, observation, analysis, creativity, concentration, persistence, self-control, sportsmanship, responsibility, respect for others, self esteem, coping with frustration, and many other positive influences which are difficult to measure but can make a great difference in student attitude, motivation, and achievement.

Additional studies, e.g. the Chess-in-the-Schools' program in NYC noted gains as high as 18.6% in math in a single year. Dr. Frank also noted improvement in numerical ability. Both of these studies will be discussed in other sections based upon the primary hypotheses of the respective researchers.

Todd Romiens, President of the Ontario Association for Mathematics Education, believes that part of the success in math noted in the New Brunswick study and others is due to the fact that chess fosters a math environment, a real life situation that stimulates math activity. Romiens stated, "The environment, whether a kitchen, a chess game, or the flooding Nile, should possess the double integrity of being concrete (supplying a relevant, 'touchable' field of activity) and dynamic (actively posing problems)." (Langen, 1995) Chess is particularly appropriate, according to Romiens, because it is well-defined, rich in problems, culturally extended, and compact.

Relationship Between Chess and Reading

The former American Chess Foundation (now known as Chess-in-the-Schools) helped organize a program and research in the USA. The New York City Schools Chess Program (NYCHESS) was founded in 1986 by Faneuil Adams, Jr. and Bruce Pandolfini. The NYCHESS program sends an experienced chess instructor to the schools to establish a chess program. The NYCHESS instructors teach five lessons and help a teacher in the building develop an ongoing program. The instructors are assisted by high school chessplayers and students from the local school who excel in chess. The youth serve as assistants and work with the pupils between visits from the NYCHESS instructor (Palm, 1990, pp. 4-5).

More than 3,000 inner-city children in more than 100 public schools had participated in the program between 1986 and 1990. The program continues to motivate young people in some of the poorest neighborhoods in the city.

Christine Palm (1990) writes:

> In its four-year existence, NYCHESS has proven that:
>
> - Chess instills in young players a sense of self-confidence and self-worth;
> - Chess dramatically improves a child's ability to think rationally;
> - Chess increases cognitive skills;
> - Chess improves children's communication skills and aptitude in recognizing patterns, therefore:
> - Chess results in higher grades, especially in English and Math studies;
> - Chess builds a sense of team spirit while emphasizing the ability of the individual;
> - Chess teaches the value of hard work, concentration and commitment;
> - Chess makes a child realize that he or she is responsible for his or her own actions and must accept their consequences;
> - Chess teaches children to try their best to win, while accepting defeat with grace;
> - Chess provides an intellectual, competitive forum through which children can assert hostility, i.e. "let off steam," in an acceptable way;
> - Chess can become a child's most eagerly awaited school activity, dramatically improving attendance;
> - Chess allows girls to compete with boys on a non-threatening, socially acceptable plane;
> - Chess helps children make friends more easily because it provides an easy, safe forum for gathering and discussion;
> - Chess allows students and teachers to view each other in a more sympathetic way;
> - Chess, through competition, gives kids a palpable sign of their accomplishments, and finally;
> - Chess provides children with a concrete, inexpensive and compelling way to rise above the deprivation and self-doubt which are so much a part of their lives (Palm, 1990, pp. 5-7).

The New York City Schools Chess Program Report is impressive, but it is based primarily on academic and anecdotal records. No statistical methods or tests were cited in the thirty-seven page report.

For statistical proof for the NYCHESS Program, one must review Margulies' (1992) "The Effect of Chess on Reading Scores: District Nine Chess Program Second Year Report."

This report evaluates the reading performance of 53 elementary pupils who participated in chess and compares their results to 1118 nonparticipants. Margulies used the paired t-test to evaluate the significance of reading gains within the chess group. He further compared the nonparticipants to the chess participants by using the chi square test.

Dr. Margulies concluded that chess participation enhances reading performance. The results of the paired t-test were significant beyond the .01 level. The chi-square test results of chessplayers in the computer-enhanced and high-scoring nonparticipants were significant at the .01 level. The comparison of results of chessplayers in the computer-enhanced program and all nonparticipants resulted in a chi square = 5.16, which is statistically significant at the .05 level.

Margulies extended his research and completed two additional studies. In June 1995, the principal of Public School 68 in the Bronx, Cheryl Coles, wrote about the impact the chess program was having on her students, “I believe we are on to something. This year our school experienced unprecedented growth in both reading and math as measured by the DRPs and the CAT. We went up school wide 11.2% in reading and 18.6% in math.”

During the 1995-96 school year, Dr. Margulies completed an expanded study that included students from four schools in Los Angeles and one school in New York City. He also incorporated a general reasoning module in his third study. Although the chessplayers average pretest scores were somewhat lower than the control group’s average, the chess groups in all five of the schools scored higher on the posttest than their peers in the control groups. The results were significant at the .001 level. What is even more remarkable about Margulies’ third study is that the chess students improved significantly over the control group even though the control group spent more time on reading. At the same time as the control group was studying reading, pupils in the chess group were pulled out of the classroom one period (45 minutes) each week for chess instruction.

While Dr. Margulies' research remains of paramount importance, other studies noted under other headings have noted similar improvement in reading. James Liptrap's study (reviewed in the math section) found that regular track chessplayers scored 4.3 points higher in reading ($p < .01$). Dr. Frank's study included in the thinking section later in this chapter also demonstrated gains in both math and reading.

Relationship Between Chess and Academic Achievement

Since 1971, the school district of Philadelphia has enjoyed state and national prominence because of the achievements of its chess teams from Frederick Douglass Elementary School and Vaux Junior High School (to which Douglass sends its graduates). Douglass Elementary School won 13 consecutive Pennsylvania State Championships (Douglass was only first outscored by my team in 1988), as well as numerous national titles. Virtually all of the Douglass-Vaux players are inner-city minority youths. The effect of this intensive chess activity has been very beneficial to the students academically. Whereas about 30% of the graduates of Vaux Junior High School drop out before completing high school, nearly all Vaux chessplayers have gone on to college. While pre and posttesting of these chessplayers has not occurred, common sense indicates that their chess experience had an extremely positive affect on them academically (Shutt, personal communication, 1989).

Academic gains have been noted by several educators. In Dr. Christiaen's research (reviewed within the thinking section), academic results at the end of the first year were significant at the .01 level, and results by the end of the second year of the study were significant at the .05 level. Although the literature discusses academic gains, only Christiaen's study presented quantitative evidence.

Relationship Between Chess and Memory

Several have surmised that chess not only demands the attribute of memory but also develops it. John Artise in "Chess and Education" writes, "Visual stimuli tend to improve memory more than any other stimuli; . . . chess is definitely an excellent memory exerciser the effects of which are transferable to other subjects where memory is necessary."

According to a two-year study conducted in Kishinev under the management of N.F. Talisina, grades for young students taking part in the chess experiment have gone up in all subjects. Teachers noted improvement in ***memory***, better organizational skills, and for many increased fantasy and imagination (Education Ministry of the Moldavian Republic in Kishinev, 1985).

Development of memory was also claimed in the Venezuela chess program (FIDE Report, 1984, p. 74), which is reviewed in the thinking section; however, no evidence of statistical significance was provided.

Relationship Between Chess and Self-Esteem

While researching the effects of chess, I found an intriguing dissertation written by Harry Milburn Turner in 1971. Entitled "An Experiment to Alter 'Achievement Motivation' in Low-Achieving Male Adolescents by Teaching the Game of Chess," Turner's research attempts to use chess as a tool to motivate low academic ninth grade boys.

From a rural Georgia junior high school, 66 subjects were identified from a ninth grade class of 403 as underachieving males with no history of failure or acceleration. The subjects were not assessed as retarded or emotionally disturbed. The boys' academic average for the previous semester was 72 percent or below, and their reading achievement was below the sixth grade level. Sixty of these low achievers were randomly assigned to participate in a teaching experiment. Ninety-two percent of the subjects were African-Americans in a school population which was 70% black.

The problem was identified as a need to increase success experiences of these boys in order to increase attitudinal changes toward intellectual tasks. It was hypothesized that a positive relationship would exist between the acquisition of a “success experience” (chess playing skill plus social reinforcement and “achievement motivation” operationally defined as self-reported changes in attitudes toward achievement in an academic setting.)

The treatment was six weeks of small group instruction in playing chess, using mastery teaching techniques, and monetary reinforcement. The dependent variables were positive changes in self-reported attitudes conducive to achievement in school. These were measured by two self-report instruments known to be positively correlated to achievement in school: the *Brookover Self-Concept of Ability Scales* (SCA, 1962) and the *Childhood Attitude Inventory for Problem Solving* (CAPS by Covington and Crutchfield, 1968). Analysis was accomplished by using analysis of variance and analysis of covariance with a Solomon 4-group experimental design (Campbell & Stanley, 1965).

The hypothesis was not fully supported by the data; however, the results were significant at the .01 level on the *SCA* measure. The treatment was considered effective in maintaining interest, imparting a skill, and generating a feeling of success. Students expressed positive attitudes toward the game, demonstrated proficiency, and 94% of the participants continued to play chess beyond the experiment. The conclusion by Dr. Turner was that six weeks was insufficient to affect significant attitudinal changes toward academic achievement by the method employed.

Other positive chess influences were noted in the Bergen County special education students, who began participating in a chess program in 1983 under the supervision of Carol Ruderman. In the 1986-87 school year, 125 students in nine schools participated. Some of the chess classes were held during regular school hours while others were scheduled after school. Most of the students were in grades 4 through 7. According to Carol Ruderman, the program coordinator, nearly all of the pupils (many of whom had adjustment problems and difficulty concentrating) showed a marked improvement in self-concept, concentration, and behavior. No attempt was made to quantitatively measure the effect of the chess program (Can Chess Improve Thinking, Social and Organizational Skill in Learning Disabled Students?), which consisted of thirteen lessons plus playing time (Ruderman, 1987).

A study treating students with similar difficulties, "The Effect of Learning to Play Chess on Cognitive, Perceptual, and Emotional Development in Children," was done in Brooklyn, New York by Steven Fried and Norman Ginsburg (1989).

> The subjects were 30 fourth and fifth grade students who were considered to be mildly delayed in their academic skills. The subjects were randomly assigned in equal numbers to one of three treatment conditions, namely, a chess instruction group, a counseling group, or a no-contact group. There were 10 subjects in each group.

After the 18 week period, all 30 subjects were administered three tests: the picture completion subtest of the Weschler Intelligence Scale for Children – Revised, a traditionally recognized, valid and reliable indicator of visual awareness to detail; the block design subtest of the same test – a test which measures spatial-relations skills; and a test called the Survey of School Attitudes – measuring school attitude.

Subjects had 36 meetings during lunch periods over eighteen weeks. This study and Turner's research had the shortest duration of the studies reviewed. In addition, the chess lessons were based on *Pawn and Queen & In Between,* which is a rather slow-moving program that requires a dozen lessons before a student has been exposed to how all the pieces move.

In the pretest, the standard one way analysis of variance test revealed no significant differences between the chess, counseling, and no-contact control groups on any of the dependent variables: picture completion, block design, and Survey of School Attitudes.

Although the primary hypothesis that the chess group would score significantly better than the counseling and the no-contact control group on each of the three tasks was not supported, a trend in the predicted direction was obtained on the picture completion task. A significant difference was found in the chess group on the Survey of School Attitudes ($p < .05$).

Another program similar to Ruderman's, "Utilizing Chess to Promote Self-Esteem in Perceptually Impaired Students" (Levy, 1987) is a part of the curriculum that has been used since 1981 in Bill Levy's self-contained class of perceptually-impaired sixth, seventh, and eighth grade pupils in Hopatcong Middle School, Hopatcong, New Jersey. The three components of this program are: 1) students are taught chess, 2) chess-related packets are distributed to students during the year, and 3) ten additional chess activities are used throughout the year.

The purpose of Levy's program is to develop learning disabled students' self-esteem and confidence. Students were given repeated opportunities in their self-contained classroom to demonstrate that they could achieve success in critical thinking activities. They also joined the school chess club.

In the 1986-87 school year, Levy decided to make a more formal assessment of the value of his program by using pre and posttests to measure gains. He used the *Piers-Harris Children's Self-Concept Scale* and *The Way I*

Feel About Myself. The instruments were administered in September 1986 and again in June 1987. In addition, another teacher assessed students' self-concept at the beginning and the end of the year using E.L. McDaniel's *Inferred Self-Concept Scale*.

The raw scores on both tests showed improvement in individual and class self-esteem. Thirteen of the fourteen students involved showed improvement. Progress was also shown after one year in critical thinking, socialization, and academic achievement. Strong evidence exists among the studies by Turner, Ruderman, Fried, Ginsburg, and Levy for supporting chess programs to develop self-esteem, but the emphasis in my studies deals more with Levy's finding that chess improves thinking skills.

Relationship Between Chess and Thinking

While learning to play almost any game can help build self-esteem and confidence, chess is one of the few that fully exercises our minds (Dauvergne, 2000). The thinking behavior in reflective reasoning and the thinking behavior needed to evaluate a chess position are analogous. These same steps are used when a chessplayer analyzes a chess position to select the best move. The chessplayer first makes a preliminary survey of the position (awareness of perplexity). In the second stage, the player evaluates the material situation, the position, and considers threats (definition of the problem). Thirdly, the competitor looks for alternative solutions to any problems (threats) and considers different variations (entertainment of suggestions or hypotheses). In this stage of analysis, the chessplayer will become involved in what de Groot calls "progressive deepening." Hearst (1969) describes de Groot's concept of progressive deepening as a situation in which a chessplayer examines the ideas of specific moves, rejects the move, and later reinvestigates the same move again and again but more deeply and with different objectives and ideas in mind. Hearst (1969) asserted:

> This process of progressive deepening may be a feature of the research strategy of scientists and mathematicians, as well as the chessplayer. Experimental psychologists, for example, often return to a specific laboratory that originally seemed unimportant, or re-examine some old hypothesis again and again—with an attempt to apply new ways of thinking each time (p. 18).

Perhaps it was this thinking process that prompted Professor Neel, Ph.D., 1970 Nobel Prize winner in physics, to say, "Research is what gives me pleasure. Research and discovery in the sciences are analogous to the game of chess" (1973). The 1994 Nobel Prize winners (two Americans and a German) for economics claim that chess thinking is directly parallel with the thinking required to do good science, in particular, those sciences where information is incomplete. (Langen, 1995)

An important element in Dewey's theoretical framework of reflective thinking is inference. According to Dewey, inference is jumping from the known to the unknown—of going from the concrete to the abstract. It involves a leap beyond what is given and already established (Dewey, 1933, p. 96). In a chess position, the player begins with what he or she knows, such as the rules of chess, the value of the pieces, his or her memory of similar positions. These are concrete elements that the chess thinker has at his or her immediate disposal. The chessplayer must dig beneath the already known to some unfamiliar territory to find solutions. This is inferential thinking, or, according to Torrance, it is original thinking.

In stage four (reasoning out the consequences of each hypothesis), the chessplayer moves from analysis to synthesis. After the player examines the variations (the various hypotheses), he/she must bring them together, reason out the consequences of each, and form a conclusion or judgment. Dewey states that analysis leads to synthesis, and synthesis perfects analysis (Dewey, 1933, p. 130).

In the final stage of reflective thinking, a judgment must be reached. The objective of reflective thought is the conclusion or the judgment. In the evaluation of a chess position, the chessplayer examines, analyzes, and synthesizes data, observations, and hypotheses to make a judgment as to what is the best move.

Adriaan de Groot, an experimental psychologist and a former member of the Dutch Olympic Chess Team, did his doctoral dissertation in the area of "Thought of the Chessplayer." De Groot (1966) found the best chessplayers (grandmasters) are the best problem solvers. The grandmaster sees the core of the problem faster than chessplayers with less ability (de Groot, 1966).

In another study by de Groot (1974), he questioned chessmasters about the problem solving process, talent in learning, concentration and focusing energy, observation, self-insight, dealing with tensions, converting failure into success, learning to socialize aggression, and how to deal with honor and fame. A discussion of all of these questions would be interesting, but would require too much space and take us away from our principal objective. The main point I want to mention is that many of the chessmasters interviewed spoke of chess as an exercise in concentration and that they had to learn to *think* in advance and how to *analyze problems* (de Groot and Prins, 1974, pp. 3, 15).

One of the key parts to a child's development is learning how to analyze problems. In fact, it is possible to discuss the effects of game-playing on children in terms of the theories of Jean Piaget about cognitive development, or intellectual maturation. Piaget (Piaget, 1954) details stage-specific games which children play in attempts to cognitively and perceptually master their environment. He believes that during the age period of approximately 11 to 15, children move from the physical trial and error to begin hypothesizing, deducing, and developing more complex logic and judgment. Piaget describes this process as moving from the "concrete" stage to the "formal" stage. He also contends that the environment of a child can speed up or slow down this maturation. Chess may provide one vehicle for accelerating it.

A study completed by Johan Christiaen (Christiaen, 1976) entitled "Chess and Cognitive Development" provides an excellent test of Piagetian theories. The experiment was conducted during the 1974-76 school years at the Assenède Municipal School in Gent, Belgium.

The trial group consisted of 40 fifth grade students (average age 10.6 years), who were divided randomly into two groups, experimental and control, of 20 students each. All of the students were given a battery of tests which included Piaget's tests for cognitive development and the *PMS* tests. These examinations were administered to all of the students at the end of fifth grade and again at the end of sixth grade. No pretest was given. The experimental group received 42 one hour chess lessons using *Jeugdschaak* (*Chess for Youths*) as a textbook.

Christiaen's goal was to use chess to test Jean Piaget's theory about cognitive development, or intellectual maturation. Since the students were an average of 10.6 at the project beginning and 11.9 years at its completion, they were expected (according to Piaget's theory) to be at the concrete level of operational thought. The purpose of the "posttest only" study was to see if the test group had progressed further towards the formal stage than the control group.

Christiaen queried: Can an enriched environment (chess playing) accelerate the transition from the <u>concrete</u> level (stage 3) to the <u>formal</u> level (stage 4)? At stage 4, the child begins hypothesizing and deducing—developing more complex logic and judgment. So the real question is "Can chess promote earlier intellectual maturation?"

A first analysis of the investigation results compared the trial and control groups using ANOVA. The scholastic results showed significant differences between the two groups in favor of the chessplayers. The academic results at the end of fifth grade were significant at the .01 level; results at the end of sixth grade were significant at the .05 level. The subtest *DGB* relations and *PMS* total were somewhat significant at the .1 level.

Dr. Adriaan de Groot ranks the Belgium study as the best experiment he has seen in educational research concerned with the differential effects of chess instruction on the mental development of school children:

> . . . The mastery of the rules (of chess) . . . mastery of standard mating procedures . . . and knowing something about a few opening systems . . . are easily defined knowledge objectives that are attainable by almost all pupils. In addition, the Belgium study appears to demonstrate that the treatment of the elementary, clear cut and playful subject matter can have a positive affect on motivation and school achievement generally . . . (de Groot, 1977)

Dr. Gerard Dullea (1982) states that Dr. Christiaen's study needs support, extension, and confirmation. In regards to the research, he also maintains ". . . we have scientific support for what we have known all along—chess makes kids smarter!"

Additional scientific support is found in the Zaire experiment (Frank, 1978), "Chess and Aptitudes," which was conducted by Dr. Albert Frank at the Uni Protestant School (now Lisanga School) in Kisangani, Zaire. The experiment was conducted during the 1973-74 school year.

Ninety-two (92) students, 16-18 years of age, were selected from the fourth year humanities class and distributed at random into two groups (experimental and control) of 46 students each. All of the students were given a battery of tests which included the *Primary Mental Abilities* test (*PMA*) in the French adaptation, the *Differential Aptitude Test* (*DAT*), the *General Aptitude Tests Battery* (*GATB*), and a *Rorschach* test. The tests were administered to all of the students both before and after the school year, except for the *DAT* which was administered only before the school year and the *Rorschach* which was given only after the school year. At the end of the first semester, a partial retesting was made. The experimental group was given a required chess course of two hours each week with optional play after school and during the Christmas and Easter vacations.

The experiment was intended to confirm two hypotheses about the influence of various abilities on chess skill and also about the influence of learning chess on the increase of certain abilities.

Frank wanted to find out whether the ability to learn chess is a function of a) spatial aptitude, b) perceptive speed, c) reasoning, d) creativity, or e) general intelligence. Playing chess well must certainly involve a high level of one or more of these abilities.

Secondly, Frank wondered whether learning chess can influence the development of abilities in one or more of the above five types. To what extent does chess playing contribute to the development of certain abilities? If it can be proven that it does, then the introduction of chess into the programs of secondary schools would be recommended, as it already has been in some countries. This hypothesis had not been the subject of any prior experimental study.

The first hypothesis would be confirmed by examining the results of the experimental group on the tests given at the beginning of the school term and correlating them with the level of chess skill attained. The second hypothesis would be proven by seeing whether significant differences exist between the results of the experimental group and the results of the control group in the aptitude tests at the end of the study.

The first hypothesis was partially confirmed. There was a significant correlation between the ability to play chess well, and spatial, numerical, administrative-directional, and paper work abilities. Other correlations obtained were all positive, but only the above were significantly so. This finding tends to show that ability in chess is not due to the presence in an individual of only one or two abilities but that a large number of aptitudes all work together in chess. Chess utilizes all modalities and abilities of an individual.

The second hypothesis was confirmed for two aptitudes. It was found that learning chess had a positive influence on the development of both numerical and verbal aptitude. The authors of the study were puzzled by the latter result. They wondered how chess playing could influence the development of verbal ability.

As mentioned earlier, this second hypothesis had not been the subject of previous experimental study, and it is highly significant in the current attempt by the American Chess School and the United States Chess Federation to establish the educational value of chess. The results of this experiment are very impressive. After only one year of chess study, the students participating in the chess course showed a marked development of their verbal and numerical aptitudes. This positive development was true for the majority of the chess students—not just for the better players. From this it is possible to infer that the introduction of chess as a regular elective course in our high schools would be of positive benefit (personal correspondence from Harry Lyman, 1981).

Sternberg (1985) lists five reasons for the surge of interest in teaching critical thinking. His fourth reason is that the ". . . Ministry for the Development of Intelligence in Venezuela showed that the teaching of critical thinking can be implemented on a massive scale with some success" (Sternberg, 1985, p. 194). For additional information about the Venezuela experiment, I wrote several letters to Dr. Luis Alberto Machado, Minister for the Development of Human Intelligence, and scoured a variety of sources. The following paragraphs share these findings.

On August 25, 1984, the Fédération Internationale des Échecs (FIDE—the international chess federation) Commission for Chess in the Schools met to review the value of chess as a part of the school curricula. Some of the benefits of chess cited in the report of the meeting included: developing memory, increasing creativity, cultural enrichment, and mental development. The commission discussed preparing documents to persuade governments to introduce chess into schools (FIDE Report, 1984, p. 74).

Also discussed at the above meeting was the massive research study made in Venezuela. The Ministry for the Development of Intelligence trained 100,000 teachers to teach thinking skills. The initial study involved a sample of 4,266 second grade students, who were taught chess.

The Venezuela chess experiment, a component part of the *Learn to Think Project,* tested whether chess can be used to develop intelligence of children as measured by the *Wechsler Intelligence Scale for Children* (*WISC*).

Both male children and female children showed an increase of intelligence quotient (IQ) after less than a year of studying chess in the systematic way adopted. Most students showed a significant gain after a minimum of 4.5 months.

The general conclusion is that chess methodologically taught is an incentive system sufficient to accelerate the increase of IQ in elementary age children of both sexes at all socio-economic levels. It appears that this study also includes very interesting results regarding transfer of chess thinking to other areas of study. (FIDE Report, 1984, p. 74)

B.F. Skinner, an influential contemporary psychologist, wrote, “There is no doubt that this project in its total form will be considered as one of the greatest social experiments of this century” (Tudela, 1987). Because of the success of the study, the chess program was greatly expanded. Starting with the 1988-89 school year, chess lessons were conducted in all of Venezuela’s schools (Linder, 1990, p. 165). Chess is now part of the curricula at thousands of schools in nearly 30 countries around the world (Linder, p. 164).

Another experiment offering scientific verification that chess improves thinking skills is “Playing Chess: A Study of Problem-Solving Skills in Students with Average and Above Average Intelligence” by Philip Rifner. This study, conducted during the 1991-1992 school term, sought to determine whether middle school students who learned general problem solving skills in one domain could apply them in a different domain. The training task involved learning to play chess, and the transfer task required poetic analysis. The study was conducted in two parts.

The first part of the study was a quasi-experiment designed to test whether transfer of training would appear in the form of enhanced performance on twelve dependent variables associated with achievement. The one of primary interest was the rated quality of the subjects’ solutions to the transfer task. Others included grades and nine sub-scores and the Total Battery score from the *CTBS/4* Achievement Battery.

The second investigation was a quantitative-descriptive study conducted to determine which aspects of problem solving behavior were related to the effects found in the first part. Think-aloud protocols, taken as the subjects solved the transfer problem, were analyzed and coded for problem solving behaviors. Results indicated several variables of interest: the number of search methods used, the number of goals set, the number of lines considered, the incidence of guessing, the number of unresolved negative evaluations, and the percentage of goals achieved. Both pre and post measures were obtained for all variables in both studies, and the results were analyzed using repeated measures analysis of variance.

Results of the quasi-experiment indicated treatment effects only for the transfer task. Results of the quantitative-descriptive study indicated treatment effects for all variables among gifted subjects but only on the number of methods used for students of average ability. Data indicated that inter-domain transfer can be achieved if teaching for transfer is an instructional goal and that transfer occurs more readily and to a greater extent among students with above average ability.

Dianne Horgan has conducted several studies using chess as the independent variable. In “Chess as a Way to Teach Thinking,” Horgan (1987) used a sample of 24 elementary children (grades 1 through 6) and 35 junior high and high school students. Grade and skill rating were correlated ($r = .48$). She found elementary players were among the top ranked players and concluded that children could perform a highly complex cognitive task as well as most adults.

Horgan found that while adults progress to expertise from a focus on details to a more global focus, children seem to begin with a more global, intuitive emphasis. She deduced, “This may be a more efficient route to expertise as evidenced by the ability of preformal operational children to learn chess well enough to compete successfully with adults” (Horgan, p. 10). She notes that young children can be taught to think clearly and that learning these skills early in life can greatly benefit later intellectual development. Former

U.S. Secretary of Education Terrell Bell agrees. In his book *Your Child's Intellect,* Bell encourages some knowledge of chess as a way to develop a preschooler's intellect and academic readiness (Bell, 1982, pp. 178-179).

Relationship of Thinking to Achievement, IQ, and Aptitude

Why is critical thinking important? Edward Glaser, coauthor of the *Watson-Glaser Critical Thinking Appraisal*, found that the skills of reflective thinking could be taught (Glaser, 1942). Glaser also found abilities measured in standardized IQ tests and abilities of reflective thinking were related but not identical (Glaser & Watson, 1964, p. 10). This is an important finding because it indicates that competency in reflective thinking skills is not the exclusive property of the academically gifted.

Educators have been concerned about the relationship between critical (reflective) thinking and academic achievement. Jenkins (1966) studied the relationship between critical thinking ability and academic success in a freshman biology course at New York University. The *Watson-Glaser Critical Thinking Appraisal* was used to test critical thinking skills. Other tests given to the students included the *California Short-Form Test of Mental Maturity*, the *Iowa Silent Reading Test*, and the *Sequential Test of Educational Progress*. Findings indicated critical thinking ability correlated with the criterion variable academic achievement at .29. However, a combination of reading ability (.33), mental ability (.24), and critical thinking produced a fairly high correlation coefficient of .72. Based on the findings of this study, the investigator also recommended that the *Watson-Glaser Critical Thinking Appraisal* be administered to incoming freshmen registering in the department of biology.

Solomon and Wurster (1978) studied the correlation between critical thinking achievement and scholastic aptitude in high school seniors. A sample of 31 male and 31 female seniors participated in this study. The subjects completed the *Watson-Glaser Critical Thinking Appraisal* and the *Preliminary Scholastic Aptitude Test*. The findings of this study indicated a strong positive relationship between critical thinking and scholastic aptitude (r=.83). Gender had little bearing on the strength of the relationship between variables, and the results suggest the inclusion of critical thinking in the high school curriculum (Solomon & Wurster, 1978).

Educators were also concerned about the relationship between critical thinking, student achievement, and IQ. Gray (1969) and Saadeh (1969) reviewed the literature and found that IQ level was not related to the ability to think critically. Furthermore, they suggested that critical thinking could be taught effectively to people two years of age or older. Gray (1969) and Saadeh (1969) also found significant gains of achievement in grades 1-6 in students who were taught critical thinking skills, and thus concluded that critical thinking can be taught in all grade levels and all subjects.

Not all instructional approaches contribute to critical thinking. In a meta-analytic synthesis of findings from 51 studies, Bansert, et al (1983) found that use of individualized teaching systems has only a small effect on critical thinking ability and student achievement in secondary school courses. They also found that individualized instruction has little effect on students' attitude toward the subject matter being taught.

Some recent research supports Dewey's promulgation that the teacher can promote critical thinking skills. Herman (1970) studied critical thinking as it related to PSSC (Physical Science Study Committee) and non-PSSC physics programs. Data were obtained by testing approximately 1,000 physics students. The *Watson-Glaser Critical Thinking Appraisal* form Zm was used; thirty physics classes from 27 different high schools were observed. The principal conclusions of this study were 1) little evidence was given to support the belief that either the PSSC or non-PSSC programs were more effective, 2) development of critical thinking skills were shown to be related to teacher-pupil interaction.

In conclusion, the literature demonstrated that reflective thinking could be taught and that chess could be used as a tool to teach complex human thinking skills. The literature also indicated that there is a positive correlation between critical thinking and academic achievement. Solomon and Wurster's study (1978) showed a high positive relationship (r = .83). (Solomon and Wurster's study had some limitations in that there was a small sample size and that the sample was not chosen by true random selection.) Jenkins' study (1988) found a smaller positive correlation between critical thinking and academic achievement (r = .29

The literature also illustrated that not all teaching methods promoted critical thinking, as indicated by Bansert's meta-analytic synthesis studies.

Many educators recommended the inclusion of critical thinking in the curriculum in one form or another. John Dewey, John Goodlad, Susan Solomon, Robert Ennis, Ernest Bayles, the National Education Association, among others, all hold that the central purpose of education is teaching the skill of reflective (critical) thinking.

Review of the Literature on the Instruments

The instruments that were used in the '79-83 Bradford study included the *Watson-Glaser Critical Thinking Appraisal* and the *Torrance Tests of Creative Thinking*. The *Watson-Glaser Critical Thinking Appraisal* is used to measure achievement in critical thinking for grade nine through college senior. This test is available in two forms, Ym and Zm, each consisting of five subtests which measure different aspects of critical thinking. The *Critical Thinking Appraisal* (*CTA*) subtests measure inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments. Each form of the *CTA* contains 100 items that can be finished in about 50 minutes.

The *CTA* was developed by Goodwin Watson, Professor Emeritus of Social Psychology and Education at Columbia University, and Edward M. Glaser, a consulting psychologist from Los Angeles. Watson developed a prototype of this test in connection with his 1925 study, *The Measurement of Fairmindedness*. In 1937 Glaser revised the test extensively for use in his research, *An Experiment in the Development of Critical Thinking*. The tests have gone through many refinements over the years. The '79-83 study used the 1963 revision of the *CTA*.

The reliability of this test has been assessed in several ways. Estimates were made of the test's internal consistency. The stability of the *CTA* was measured by calculating split-half reliability coefficients for ten norm groups. The odd-even split-half coefficients corrected by the Spearman-Brown formula range from .85 to .87 on form Ym and from .77 to .83 on form Zm (*CTA* Manual, 1964). The stability of response over time was assessed by administering the test twice to a group of college students (N=96) with an interval of three months between testing periods.

As stated in the *Critical Thinking Appraisal* manual, the validity of a test is not a characteristic that can be designated by a single correlation coefficient. The extent to which the *CTA* measures a sample of specific objectives of an instructional program is an indication of its content validity (Watson-Glaser manual, 1964).

Factor analysis of the *CTA* with other measures of intelligence generally show that the *CTA* gauges a dimension of ability that can be seen as distinct from overall intellectual ability. Glaser found the correlation of the *CTA* to measures of verbal intelligence to range from .55 to .75 with the median at .68 (Watson-Glaser manual, 1964).

An evaluation was made by a panel of psychologists of the reliability and validity of both the *Watson-Glaser Critical Thinking Appraisal* (form Ym) and the *Cornell Critical Thinking Test* (level X). As criteria, the ten essential validity standards and five essential reliability and measure error standards (from the 1974 publication *Standards for Educational and Psychological Tests*) were used. The panel was composed of 12 psychologists with Ph.D. degrees. In general, both the *CTA* and the *Cornell Critical Thinking Test* appeared favorable in terms of reliability and validity. Modjeski and Michael found (1983): "Although in terms of overall mean ratings assigned by judges across the ten validity standards, no significant differences were observed for [between] the two measures."

Both tests were judged favorably in terms of use of acceptable ways of reporting data, description of procedures used to determine reliability coefficients, and standard errors of measurement (Modjeski & Michael, 1983).

The instrument used to measure creativity in the '79-83 Bradford study (also known as "The ESEA Title IV-C Project: Developing Critical and Creative Thinking") was the *Torrance Tests of Creative Thinking* (TTCT). I feel the figural format is best suited for use with primary age students; therefore, I opted to use the verbal format. The Verbal Tests consist of seven parallel tasks. Each task brings into play somewhat different mental processes, yet requires the subject to think divergently in terms of possibilities (Torrance, 1974, p. 4).

The key portions on the test include: “ask-and-guess” activities, a “product improvement” activity, “unusual uses” activities, an “unusual questions” activity, and the “just suppose” activity. Each individual test is scored on the basis of fluency, flexibility, originality, and elaboration.

The “ask-and-guess” gives individuals the opportunity to “express their curiosity and give a picture of their ability to develop hypotheses and think in terms of possibilities” (Torrance, p. 11). Torrance argues that the essence of creative thinking, especially creative scientific thinking, is captured in the processes of asking and guessing. Curiosity has long been expressed in terms of the quantity and type of questions asked.

The “product improvement” activity has proven one of the most dependable tests. Most people recognize this type of thinking as practical and desirable. Subjects usually find it to be an interesting task.

The “unusual uses” activities are very similar to the *Guilford’s Brick Uses Test*. In these tests, the subjects have to generate creative uses for tin cans and cardboard boxes.

The “unusual questions” activity was modified from a technique used by Robert C. Burkhart of Pennsylvania State University (1961). Burkhart developed the *Unusual Questions Test* to measure what he calls “divergent power.” For a high degree of creative achievement, Burkhart maintains that divergent power is absolutely essential.

The “just suppose” activity was adapted from the consequences type test in Guilford’s (1959) battery of tests. This test tries to encourage the subjects to fantasize more. In order to score successfully, the individual taking the test must play along and think of all the consequences or outcomes that would result from an improbable situation.

The *Torrance Tests of Creative Thinking* were developed by Dr. E. Paul Torrance (Distinguished Professor Emeritus and pioneer in research on the identification and development of creative potential) in response to the need to detect and measure, in a useful way, creative potential. The reliability of these tests has been evaluated in numerous studies. Dalbec (1966) obtained test-retest reliability coefficients of .59 for fluency, .35 for flexibility, and .73 for originality. Other studies obtained higher reliability coefficients. Gorlaski (1964): fluency=.82, flexibility=.78, originality=.59, total battery=.83. Eherts (1961) reported a reliability coefficient of .88 for the battery.

As stated in the manual, "The concept of an overall validity coefficient for tests of creative thinking ability is grossly inappropriate" (Torrance, p. 21). To insure content validity, a consistent and deliberate effort was made to base the test stimuli, tasks, instructions, and scoring procedures on the best theory and research available:

> Analyses of the lives of indisputably eminent creative people, research concerning the personalities of eminent creative people, the nature of performances regarded as creative, research and theory concerning the functioning of the human mind, and the like have been considered in making decisions regarding the selection of test tasks. A deliberate and consistent effort has also been made to keep the test tasks free of technical or subject matter content. (Torrance, p.22)

Due to low interscorer reliability in evaluating elaboration and my secretary's difficulty in scoring this particular aspect, I elected not to compare gains in elaboration, but to concentrate on fluency, flexibility, and originality.

The advantages of the *Torrance Tests of Creative Thinking* include the fact that the test has been widely used in research with individuals of many ages, including children (who seem to enjoy the challenge of the tests). The biggest disadvantages were the training and the amount of time to score the tests. Some of the other tests reviewed (e.g. Mednick's *Remote Associates Test*) were too difficult for younger students, and they lacked long range validity evidence.

For my 1987-88 study ("Developing Memory and Verbal Reasoning"), I chose to use the Memory subtest and the Verbal Reasoning subtest of the *Test of Cognitive Skills*. The *TCS* is administered annually to all grade levels throughout the school district, and data are readily available. These tests reflect abilities such as problem solving and remembering.

The Memory test measures the student's ability to remember previously presented material. This test has two parts: 1) the Memory Learning Materials, containing sample items and 20 obscure words and their definitions and 2) after an interval of about 25 minutes, the Memory test is given. The student is asked to match the words and definitions that were given in the Memory Learning Materials. Obscure words were selected so that a student's recall of the material would not be influenced by previous knowledge. The *TCS* Memory test is not dependent on reasoning or reading comprehension skills (*Test of Cognitive Skills Examiner's Manual,* 1981, p.2).

The Verbal Reasoning test measures the student's ability to determine relationships and reason logically. Some of the items ask the student to infer relationships between separate but related sets of words. In some questions, the student must identify fundamental aspects of objects or concepts. A final type of problem requires the student to deduce logical conclusions from information given in short passages. The Verbal Reasoning test is comprised of twenty items that are dependent upon both reasoning and reading comprehension skills.

The *TCS* was standardized in 1980 by administering the battery to a national sample of 82,400 students in grades 2 through 12. The sample was stratified by geographic region, type, size of district, and a demographic index based on community characteristics related to district achievement.

In the section on validity, the 1983 *Technical Report* for the *Test of Cognitive Skills* states:

> *TCS* does not claim to measure all aspects of cognitive ability. Since it is intended for use in schools, emphasis is placed on abilities of a relatively abstract nature that are important for success in an educational program.

To insure content validity, a consistent and deliberate effort was made to base the test items on the best theory and research available. A staff of professional item writers researched and developed questions for the tests. All items and directions were carefully reviewed for accuracy. Comparisons of item performance were made across grade level, as well as across ethnic groups. To obtain object parameter estimates, LOGIST was run separately on each test.

Product-moment intercorrelation coefficients and related summary data were developed using the IRT method. Each item was rated for adequacy, quality, bias, discrimination, and other factors.

To assess reliability of the *TCS*, the Kuder-Richardson formula 20 (KR 20) was used. The formula provided a KR 20 coefficient of .84 for level 3 of the Memory test used with sixth graders and a KR 20 coefficient of .81 for the same level of the Verbal Reasoning test.

Summary

Historically, chess has been used as a research tool by many psychologists. Alfred Binet, who in 1893 researched memory in blindfolded chessplayers, was one of the earliest psychologists to use chess to study memory (Hearst, p. 22, 1969). Freud was the first psychoanalyst to mention the game of chess, when in 1913 he stated the steps required to master chess were like learning the psychoanalytic techniques (Hearst, 1969).

The literature is filled with research which indicates that chess can be utilized as a tool to study the type of thinking referred to as problem solving. Scurrah (1971) suggests there has been a rebirth of the use of chess for studying complex human problem solving thinking (p. 209).

The academic works reviewed have helped to provide the basis for the questions and hypotheses for these studies: chess can be used as a vehicle to investigate human thought. Reports and findings of empirical studies indicate that chess can be used to investigate problem-solving. Schmidt (1982) states that chess needs to become part of the school curriculum. He asserts, "students will develop analytical, synthetic, and decision making skills which they can transfer to real life" (p. 3).

Horgan (1987) also argues that chess can develop thinking skills. Dr. Schiff's research (1991) concluded that "Fluency, flexibility, originality, and elaboration are cognitive behaviors which can be successfully taught to our gifted student population through the art of chess."

There has been universal consensus in the literature that the teaching of reflective thinking is needed in our schools. Dewey persistently argued this point.

Furthermore, research has demonstrated that the ability to think critically can be taught, measured, and evaluated. Many researchers indicated that critical thinking could be taught in all subjects and grade levels. My 1979-83 (Ferguson, 1983) study hypothesizes that chess, computer programming, and a variety of other mentally challenging activities can be used as tools to teach critical thinking in our schools. In a document submitted to the U.S. Department of Education, Hall (1983) recommended that chess be taught in the schools. He indicated that chess is a mentally demanding activity which teaches the importance of planning. He also stated, "Proficiency in chess seems to be related to inherent logic, problem solving ability, temperament, versatility in thinking, and appreciation for the beauty of the game" (p. 8).

Not only do my research studies have the potential to offer empirical support for Hall's recommendation concerning teaching chess in the elementary and secondary schools, they may also provide data for study in other areas. Krogius, in his book *Chess Psychology*, indicated that Lasker's classification of styles of thinking needs more investigation (p. 15). According to Krogius, more considerations are needed regarding the qualities of chess thinking and the structure of the thought process in the selection of a move.

Chapter III. Methodology or Procedures

There's not the mystery in ten murders that there is in one game of chess.
–Arthur Conan Doyle

Organization of Chapter III

I. Reviews the research design for each of the three studies.
II. Explains the selection of the subjects in the investigations.
III. Discusses the instruments used in each of the studies.
IV. Presents classroom procedures, including daily lessons, course objectives, methods, materials, and evaluation procedures.
V. Deals with data collection.
VI. Examines the statistical tests and procedures employed to analyze the data collected.
VII. Lists limitations for each of the three studies.
VIII. Summarizes the contents of the third chapter.

Research Design

The four year ESEA project was constructed using the pretest/posttest control group design. Campbell and Stanley maintain that the pretest/posttest control group design is a true experimental design (Campbell & Stanley, 1963, p. 13). The goal of this control group design was to reduce the effects of maturation, testing, regression, and mortality.

I served as project director and administered tests to all groups and provided all treatments so as to avoid extraneous variable factors that might be created by the introduction of two or more experimenters.

The 1986 pilot study was also conducted using the control group design; however, no dependent variable was used. The existing scores on SAT tests or practice tests were used as the pretest for the SAT group and current ratings were used for the chess group.

The 1987-88 research used a one group pretest/posttest design. To determine the statistical significance of the increase, the empirical data collected from this group on the Verbal Reasoning and Memory tests were compared to the national norms as well as to their respective gains from the pretests to the posttests.

Selection of Subjects

The population sampled in Study I was comprised of gifted students residing in Bradford, a small community of just over 10,000 individuals. The total school population was about 3,600, and the entire number of students identified as gifted totaled 168 in grades K-12.

The subjects sampled in the 1979-83 study are all students identified by the Bradford Area School District as being mentally gifted with a minimum intelligence quotient of 130, as measured by the *Wechsler Intelligence Scale for Children*. All students included in the project were in grades seven through nine. Multiple groups of students were used. There were a total of 32 participants in the 1979-80 school year, 29 participants in the 1980-81 term, 26 for the 1981-82 year, and 24 subjects in the 1982-83 period. A total of 111 students participated in the ESEA funded project. Due to families relocating, midterm entries into the program, and scheduled test dates, only 94 completed both the pre and posttest.

Students were assigned to groups according to their specified interest areas discussed at an individualized education planning conference with their parents. Two of the most popular independent variables were computers and chess. Several other options were available. Some (e.g. Future Problem

Solving) were available for only one school year (1979-80) and then discontinued due to a lack of interest on the part of the students.

To simplify and reduce the quantity of statistical calculations and tables, the data from the four year study have been combined. There is no reason, *ex-ante*, that bias would be introduced by the combination of the annual data.

The subjects sampled during the February 6 - April 3, 1986, pilot study were more diverse. Students of all ranges were invited to participate. A total of 42 students in grades two through twelve were involved in the project. Many were gifted, some were average, and others were learning disabled. Students were self-selected for either the SAT or chess group; they were not randomly assigned.

The participants in the September 1987-88 study were all sixth graders in the same self-contained classroom. The IQ range was from 87 to 123. The average IQ was 103. A total of 14 students completed both pre and posttests.

Instrumentation

For the 1979-83 Title IV-C project, two primary instruments were used: *The Watson-Glaser Critical Thinking Appraisal* (forms Ym and Zm) and the *Torrance Tests of Creative Thinking* (verbal forms A & B).

The 1986 pilot study tested students only in the actual performance of the independent variables selected: chess or SAT preparation. No dependent variable was used.

The 1987-88 project tested students by comparing their scores on the Memory and Verbal Reasoning subtests of the *Test of Cognitive Skills* level 3, which were administered on September 17, 1987, and then again on June 2, 1988.

Classroom Procedures

Study I

Students participating in the 1979-83 study received both group instruction and independent learn-by-doing experiences for approximately two hours each week in the resource room. The chess group received weekly group instruction on rules, general principles, tactical motifs, etc. The main text for the first two project years was the *Collier Guide to Chess* by Gerald Abrahams. Later in the project (81-83), the main texts used were *Simple Chess Tactics* and *Simple Checkmates* by A.J. Gillam. Quizzes were given based upon the day's lesson. Students then played a game of chess.

Please see Appendix A for a summary of course objectives, instructional methods, materials, evaluation procedures, criteria of successful performance, basic skills checklist, sample quizzes, analysis sheets, and other course related materials. The students studying problem solving with computers received a combination of group instruction, independent reading, weekly quizzes, and hands-on, learn-by-doing exercises on the computer. For a course outline of the *Problem Solving with Computers* text, objectives, strategies, resources, evaluation procedures, and criteria of successful performance, please turn to Appendix B.

Study II

The weekly time frame for the 1986 pilot study was about the same (two hours a week), and it used the same basic texts and objectives with a few additions. Students were asked to describe their thinking systems when trying to solve a problem. They discussed ways to improve their own thinking system. Pupils were also expected to generate a number of ways that they could transfer their chess thinking skills/processes to everyday problems. This was a recurring theme throughout the project. All students were required to integrate different modalities into their problem solving practice on a weekly basis. If a student was a visual thinker, he/she was required to use a typed list of questions before arriving at a solution. If an individual was an auditory learner and typically "talked" himself/ herself through problems, he or she was required to play with a chess board or chess computer without pieces to force better visualization. In addition, advanced students were required to write their own objectives and select their own texts. Most spent additional hours completing these objectives.

Study III

Similar strategies were employed with the sixth grade self-contained classroom during the 1987-88 school year (Study III), but the process was accelerated because the lessons were often given two or three times a week. Students played games daily in the classroom after they had completed their assignments and during recess.

The following represents a typical day's lesson plan format for each of the three chess studies. Specific lessons and format are included for those wishing to replicate these studies.

Typical Lesson Plan

The quizzes for the lower levels are almost exclusively diagrams based on each lesson plan, which require students to analyze the position and select the best move. According to former Soviet chess teacher Yevsey Gelman, the ". . . method of diagrams shows the best results in development of imagination and calculations" (Gelman, 1984).

STEP 1

REVIEW the last lesson. (*approximately 10-15 minutes*)

STEP 2

INTRODUCE new concept and teach lesson. (*about 30 minutes*)

STEP 3

QUIZZES—all students do the quiz while the concept is fresh in their minds. If class time does not permit, students may be required to do at least one example to check for comprehension of the concept, and the quiz may be used as a take-home-quiz or assignment. (*generally 10-15 minutes*)

STEP 4

PLAY supervised games for round robin. Touch move. (*1 hour*)

STEP 5

INDIVIDUAL REVIEW—While students are playing games, the instructor reviews the quizzes with students **individually** (or in pairs) and checks them on basic skills. As the student successfully completes each objective, the instructor dates it and initials each pupil's skill checklist.

When the student has successfully completed all quizzes and objectives for the current level, he/she receives a certificate of achievement indicating what level has been completed.

Basic Chess Skills Level I

This is the introductory course provided to the chess treatment group in the experimental studies conducted by me. Some students in the project advanced beyond this level. The goal at this preliminary level is to equip the student with the necessary skills to compete at the novice level.

Piece Movement

Short Term Objective:

Each student will learn and demonstrate how the Rook, Bishop, Queen, King, Knight, and pawn move.

Every pupil will learn the correct starting position for the pieces.

Materials:

Demonstration board and pieces, tournament sets, *Let's Play Chess* (summary of chess rules), and a skill checklist for each student.

Instructional Method:

The moves will be demonstrated by a student or the instructor on a demonstration board. Students will take turns demonstrating the correct movement of the pieces and their correct starting position on the chessboard. Pass out copies of *Let's Play Chess* to all participants and briefly review the contents. Students will play supervised games.

Evaluation Procedures:

The instructor will watch students set up boards and play and monitor moves for legality. The instructor will offer suggestions and answer questions as necessary to maintain legal moves during the games.

Touch Move Rule/Sportsmanship

Short Term Objective:

Each student will explain and use the touch move rule.

Materials:

Demonstration board and pieces, tournament sets.

Instructional Method:

The touch move rule will be stressed from the first day of instruction, and students will be required to use it in all of their games. Students will discuss what good sportsmanship is, and all will be encouraged to use and promote it.

Evaluation Procedures:

The instructor will start the supervised playing time with a reminder about touch move being an aspect of good sportsmanship and will ask students to wish their opponents good luck while shaking hands.

Diagonal, Rank, and File

Short Term Objective:

Each student will explain the terms diagonal, rank, and file.

Materials:

Demonstration board and pieces, tournament sets.

Instructional Method:

The instructor will point to the vertical, horizontal, and diagonal rows on the chessboard and ask which type of row it is. Students will play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the concept with them in pairs.

Relative Value of Pieces

Short Term Objective:

Each student will state the relative value for the Rook, Bishop, Queen, King, Knight, and pawn.

Materials:

Demonstration board and pieces, tournament sets, poster showing values.

Instructional Method:

The poster chart will be used to introduce the students to the relative value of the pieces. The instructor will ask the students why the value is relative and discuss the power of the individual pieces. The instructor will review a short game on a demonstration board to illustrate captures and material advantage. Students will play supervised games and attempt to gain a material advantage.

Evaluation Procedures:

The instructor will ask students individually to explain the relative value of each piece without the aid of the poster chart.

How to Castle

Short Term Objective:

Each student will learn why it is important to castle and demonstrate how to castle on both the King-side and the Queen-side.

Materials:

Demonstration board and pieces, tournament sets.

Instructional Method:

The moves will be demonstrated by a student or the instructor on a demonstration board. Students will take turns demonstrating the correct way to castle on both sides of the board. The instructor will lead a discussion on the reason for castling and then demonstrate the point by reviewing a game in which the opponent loses because he does not castle. Students will play supervised games.

Evaluation Procedures:

The instructor will watch students set up boards and play and monitor moves for legality. All students will be required to castle early.

Pawn Promotion

Short Term Objective:

Each student will explain and demonstrate pawn promotion.

Materials:

Demonstration board and pieces, tournament sets, Pawn Promotion Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the pawn promotion. The instructor will review a brief game on a demonstration board to illustrate the pawn promotion. Students will complete the Pawn Promotion Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the quiz with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Center and Development

Short Term Objective:

Each student will explain the terms center and development and apply the ideas in supervised play.

Materials:

Demonstration board and pieces, tournament sets.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to suggest moves. Students will take turns suggesting moves that fight for the center and/or develop new pieces. The instructor will review a brief game on a demonstration board to illustrate the importance of the center and development. Students will play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the concept with them in pairs.

Check and Checkmate

Short Term Objective:

Each student will recognize the difference between check and checkmate. Each will be able to identify the three ways to get out of check.

Materials:

Demonstration board and pieces, tournament sets, Check/Checkmate Quiz, reference list of mating patterns.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students whether the position is a check or a checkmate. The instructor will review a short game on a demonstration board to illustrate checks and checkmates. The leader will stress that checkmate is the ultimate goal of the game. Mating patterns will be reviewed weekly until pupils have demonstrated mastery. Students will play supervised games.

Evaluation Procedures:

The instructor will ask students individually to demonstrate check and checkmate. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Algebraic Notation

Short Term Objective:

Each student will learn to write and say chess moves in algebraic.

Materials:

Demonstration board and pieces, tournament sets, Notation Quiz.

Instructional Method:

Most students will be familiar with the “Battleship” game. The instructor will explain the concepts of coordinates using “Battleship” as an example. The group leader will solicit from pupils other items that use a similar coordinate system. The demonstration board should clearly have all ranks and files labeled. Students will play supervised games.

Evaluation Procedures:

The instructor will ask students to write answers on quizzes in algebraic notation and to name the squares on the demonstration board using algebraic when suggesting moves.

Stalemate

Short Term Objective:

Each student will recognize and explain the difference between stalemate and checkmate.

Materials:

Demonstration board and pieces, tournament sets, Stalemate/Checkmate Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students whether the position is a stalemate or a checkmate. The instructor will review a short game on a demonstration board to illustrate stalemate. Students will play supervised games.

Evaluation Procedures:

The instructor will review the Stalemate/Checkmate Quiz with students individually to be certain they understand the difference between checkmate and stalemate. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Draw by Perpetual

Short Term Objective:

Each student will recognize that a perpetual check is a draw.

Materials:

Demonstration board and pieces, tournament sets, Perpetual Check Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to explain how to force the perpetual. The instructor will review a brief game on a demonstration board to illustrate perpetual check. Students will play supervised games.

Evaluation Procedures:

The instructor will review the quiz with students individually to be certain they understand the concept of perpetual check. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Draw by Repetition

Short Term Objective:

Each student will explain and demonstrate a draw by repetition.

Materials:

Demonstration board and pieces, tournament sets, Draw by Repetition Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the draw by repetition. The instructor will review a brief game on a demonstration board to illustrate draw by repetition. Students will play supervised games.

Evaluation Procedures:

The instructor will review the quiz with students individually to be certain they understand the concept of draw by repetition. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Use of Chess Clock

Short Term Objective:

Each student will demonstrate the correct setting and use of a chess clock. Each will learn that the clock is an expensive device, which must be handled with care.

Materials:

Chess clocks, tournament sets.

Instructional Method:

The instructor will explain and demonstrate how to set a chess clock, discuss its purpose, and show how to use it correctly. The teacher will have a catalog on hand displaying the types of chess clocks and prices. Students will play supervised games with chess clocks.

Evaluation Procedures:

The instructor will observe students while they set the chess clocks and monitor their games to assure they are using the clocks correctly.

Use of Chess Computer

Short Term Objective:

Each student will demonstrate the correct use of a chess computer and/or chess software.

Materials:

Chess computers and/or software and compatible computer.

Instructional Method:

The instructor will explain and demonstrate how to use a chess computer and discuss how it can help students to become stronger players. Students will play supervised games with the chess computers.

Evaluation Procedures:

The instructor will observe students while they use the chess computers and monitor their games to make certain they are interpreting the computers' moves correctly.

King and Rook Mate

Short Term Objective:

Each student will demonstrate checkmate using King and Rook against a lone King.

Materials:

Demonstration board and pieces, tournament sets, Rook Checkmate Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to explain how to force the checkmate. The concepts of confinement, opposition, and compulsion will be discussed. Given the position of black King on e8, white King on e6, and white Rook on e4, students will practice checkmating each other with Rook and King. The instructor will review a brief game on a demonstration board to illustrate how to checkmate using a rook. Students will complete the Rook Checkmate Quiz and then play supervised games.

Evaluation Procedures:

The instructor will observe students while they take turns checkmating each other with the Rook and will review quiz answers with pairs of pupils after they finish their games. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

King and Two Bishop Mate

Short Term Objective:

Each student will demonstrate checkmate using King and two Bishops against a lone King.

Materials:

Demonstration board and pieces, tournament sets, Bishop Checkmate Quiz.

Instructional Method:

The instructor will first show the step-by-step procedure for the mating net. He will then set up positions on the demonstration board and ask the students to explain how to force the checkmate. Students will practice checkmating each other with two Bishops and King. The instructor will review a brief game on a demonstration board to illustrate how to checkmate using the two bishops. Students will complete the Bishop Checkmate Quiz and play supervised games.

Evaluation Procedures:

The instructor will observe students while they take turns checkmating each other with the two Bishops. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

King and Queen Mate

Short Term Objective:

Each student will demonstrate checkmate using King and Queen against a lone King.

Materials:

Demonstration board and pieces, tournament sets, Queen Checkmate Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to explain how to force the checkmate. Students will practice checkmating each other with the Queen. The instructor will review a brief game on a demonstration board to illustrate how to checkmate using a Queen. Students will play supervised games.

Evaluation Procedures:

The instructor will observe students while they take turns checkmating each other with the Queen. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Queen Fork

Short Term Objective:

Each student will demonstrate a Queen fork.

Materials:

Demonstration board and pieces, tournament sets, Queen Fork Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the forks. Students will practice forking each other with the Queen. The instructor will review a brief game on a demonstration board to illustrate Queen forks. Students will play supervised games.

Evaluation Procedures:

The instructor will observe students while they take turns forking each other with the Queen. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Knight Fork

Short Term Objective:

Each student will demonstrate a Knight fork.

Materials:

Demonstration board and pieces, tournament sets, Knight Fork Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the forks. Students will practice forking each other with the Knight. The instructor will review a brief game on a demonstration board to explain Knight forks. Students will complete the Knight Fork Quiz and then play supervised games.

Evaluation Procedures:

The instructor will observe students while they take turns forking each other with the Knight. As the pupils finish playing their games, the leader will review their quizzes with them. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Rook Fork

Short Term Objective:

Each will demonstrate an understanding that the Rook is equally powerful on the edge of the board as in the center. Each student will show a Rook fork.

Materials:

Demonstration board and pieces, tournament sets, Rook Fork Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the Rook forks. The power of the Rook as a major piece will be reexamined. The instructor will review a short game on the demonstration chessboard to illustrate Rook forks. Students will complete the quiz and play supervised games.

Evaluation Procedures:

The instructor will observe students while they take turns forking each other with the Rook. Teacher will review the Rook Fork Quiz with pairs of pupils as they complete their games. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

King Fork

Short Term Objective:

Each student will demonstrate a King fork.

Materials:

Demonstration board and pieces, tournament sets, King Fork Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the forks. Students will pair off to complete the King Fork Quiz and play supervised games.

Evaluation Procedures:

The instructor will observe students while they take turns executing King forks. As the students finish their games, the instructor will review the student quizzes with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Bishop Fork

Short Term Objective:

Each student will demonstrate a Bishop fork.

Materials:

Demonstration board and pieces, tournament sets, Bishop Fork Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the forks. Students will take turns showing how to use a bishop fork. The instructor will review a brief game on a demonstration board to illustrate bishop forks. Students will complete the Bishop Fork Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the student quizzes with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Pawn Fork

Short Term Objective:

Each student will demonstrate a Pawn fork.

Materials:

Demonstration board and pieces, tournament sets, Pawn Fork Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the forks. Students will take turns showing how to use a Pawn fork. The instructor will review a brief game on a demonstration board to illustrate Pawn forks. Students will complete the Pawn Fork Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the student quizzes with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Pin

Short Term Objective:

Each student will demonstrate a Pin.

Materials:

Demonstration board and pieces, tournament sets, Pin Quizzes.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the pins. Students will take turns showing how to take advantage of pinned pieces by attacking them a second time. The instructor will review a brief game on a demonstration board to illustrate pins. Students will complete a Pin Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the student quizzes with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Back Rank Mate

Short Term Objective:

Each student will demonstrate a back rank mate.

Materials:

Demonstration board and pieces, tournament sets, Back Rank Mate Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the back rank mates. Students will take turns mating each other to reinforce the concept. The instructor will review a brief game on a demonstration board to illustrate back rank mates. Students will complete the Back Rank Mate Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the student quizzes with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Skewer

Short Term Objective:

Each student will explain and demonstrate a skewer.

Materials:

Demonstration board and pieces, tournament sets, Skewer Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the skewers. The instructor will review a brief game on a demonstration board to illustrate the use of skewers. Students will complete the Skewer Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the quiz with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Discovered and Double Checks

Short Term Objective:

Each student will explain and demonstrate discovered checks.

Each will show what a double check is.

Materials:

Demonstration board and pieces, tournament sets, Discovered and Double Checks. Quiz

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the discovered and double checks. The instructor will review a brief game on a demonstration board to illustrate the use of discovered and double checks. Students will complete the Discovered and Double Checks Quizzes and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the quiz with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Discovered Attacks

Short Term Objective:

Each student will explain and demonstrate discovered attacks.

Materials:

Demonstration board and pieces, tournament sets, Discovered Attacks Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the discovered attacks. The instructor will review a brief game on a demonstration board to illustrate the power of the discovered attack. Students will complete the Discovered Attacks Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the quiz with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Double Attacks with Check

Short Term Objective:

Each student will explain and demonstrate double attacks with check.

Materials:

Demonstration board and pieces, tournament sets, Double Attacks with Check Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the double attacks with check. The instructor will review a brief game on a demonstration board to illustrate the power of the double attacks with check. Students will complete the Double Attacks with Check Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the quiz with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Double Attacks without Check

Short Term Objective:

Each student will explain and demonstrate double attacks without check.

Materials:

Demonstration board and pieces, tournament sets, Double Attacks without Check Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the double attacks without check. The instructor will review a brief game on a demonstration board to illustrate the power of the double attacks without check. Students will complete the Double Attacks without Check Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the quiz with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Remove the Defender

Short Term Objective:

Each student will explain and demonstrate the remove the defender concept.

Materials:

Demonstration board and pieces, tournament sets, Remove Defender Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to solve the problem by removing the defender. The instructor will review a brief game on a demonstration board to illustrate the power of removing the defender. Students will complete the Remove the Defender Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the quiz with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Overworked Pieces

Short Term Objective:

Each student will explain and demonstrate the concept of overworked pieces.

Materials:

Demonstration board and pieces, tournament sets, Overworked Pieces Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the overworked pieces in the problems. The group leader will review a brief game on a demonstration board to illustrate the force of finding the overworked pieces. Students will work together in pairs to complete the Overworked Pieces Quiz. After completing the quiz, they will play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the Overworked Pieces Quiz with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

King Opposition

Short Term Objective:

Each student will demonstrate King opposition and how to use it.

Materials:

Demonstration board and pieces, tournament sets, King Opposition Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the correct move to obtain opposition or to avoid it. The instructor will review an endgame on a demonstration board to illustrate the value of King Opposition. Students will complete the King Opposition Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the quiz with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Game Analysis

Short Term Objective:

Each student will play over the moves of one of his own games and analyze it with the instructor and his opponent.

Materials:

Demonstration board and pieces, tournament sets, written analysis of game.

Instructional Method:

The instructor will analyze a brief game modeling key questions and methods for the students to follow in their game analysis. A written example of a game analysis will be given to each student to review in preparing individual annotation and analysis. Students will play supervised games and review them with the opponent and the instructor upon conclusion of the game.

Evaluation Procedures:

As the students finish their games, the instructor will listen to them as they review their games. The instructor will correct inaccurate assumptions and steer students toward more comprehensive understanding of the problems by asking focused questions and reviewing general principles.

Later Additions

To challenge students to focus their thinking, the following additions were made to the above lessons for the 1986 pilot study and for the 1987-88 experiment. All participants in these later studies were required to complete the *Swassing-Barbe Modality Checklist*, write a paragraph about what goes on in their heads when solving a problem, and explain their thinking systems to their peers. Frequent questions were asked, such as: "What was going on in your head while you were thinking about this problem?"; "Why did you decide on this move?"; "What other moves did you consider, and why did you discard them?"; "What was your reason for this solution?"

Annual Goals for Study II and III

The goals for the students in Study II and III were revised and included the following:

1) to use higher level thinking skills in analyzing, synthesizing, and evaluating
2) to develop the capacity to produce better solutions to problems
3) to become proficient in creative problem solving techniques

Student Objectives

1) make a mental and/or written record of what he/she has observed
2) look at two positions and describe how they are similar and different
3) organize information concerning his/her chess study in logical way
4) identify a problem and list possible solutions
5) list patterns in thinking to help him/her express more accurately what he/she means
6) define the problem
7) select pertinent information for the solution of the problem
8) formulate and select relevant and promising hypotheses
9) draw conclusions validly and judge the validity of inferences

10) reflect on how he/she thinks and solves problems

11) develop a thinking system based on his/her individual thinking style

12) write down the thinking system and explain it to peers

13) combine, integrate, and adapt visual and auditory thinking systems to improve thinking performance

14) compare different thinking systems, e.g. scientific method

15) apply his/her modified thinking system to a variety of problems

16) generate a number of relevant responses to specific problems

17) examine a principle and apply the concept to specific problems

18) list a variety of solutions for a given problem

19) establish criteria for analyzing the solutions

20) narrow the number of solutions based upon the criteria

21) embellish solutions by visualizing a fantasy position

22) delve into intricate problems or ideas

23) present evidence to support ideas and proposed alternatives

24) seek and consider intricate solutions rather than accepting the easy one

25) visualize and build mental images

26) visualize a series of images representing the steps of a solution

27) develop a series of questions to solve problems

28) describe what is going on inside his/her head when he/she is trying to solve a problem

29) generate unique, new or original alternatives

30) follow sequential steps in thinking

31) improve in the use of a specific form of thinking

32) explore affect of problem variables

33) practice inquiry methods to be able to become more discriminating in decisions

34) discipline his/her thinking to delay decision making until sufficient alternatives/data are explored

35) analyze challenging positions

36) annotate problems/games that are creative or highly instructive

37) take notes on general principles and concepts

38) practice his/her thinking system in a laboratory or competitive setting weekly

39) notate a minimum of one game per week

40) compete in several rated chess tournaments

41) evaluate his/her own tournament games individually and with team members

Instructional Methods, Materials, & Activities

—USA Junior Chess Olympics Training Program

—Teaching the 4th "R"—Reasoning Curriculum

—Compete in the USA Junior Chess Olympics Tournament

—participate in a minimum of three rated chess tournaments prior to States

Evaluation Procedures & Criteria for Successful Performance

—3 out 4 correct on quizzes

—achieve one or more of the following:

Earn a 10% differential [0.1(2200-Current Rating) = Differential] between current rating and a master rating ***OR*** a performance rating equal to current rating plus 100 points ***OR*** receive a plus score in average of tournaments attended. Student must accomplish at least one of the above in order to participate in states and nationals.

—transfer thinking skills to successfully solve real life problems

—teacher, self, and peer evaluation

Positional Thinking Versus Tactical Thinking

It is beyond the scope of this paper to review all the lessons used to teach the foregoing objectives; however, a brief summary and a few examples are in order. First it is important to remember that the students in Study I were not exposed to most of the objectives stated above. Most of the students were trained to be tactical thinkers (combination players) first and foremost. Strategy in the early study dealt only with basic general principles. With the expanded student objectives, it is possible to see that students were not only developing plans for playing their games but were also creating their own systems to develop those plans and strategies. The end goal was to develop a harmony between positional thinking and tactical thinking: the eclectic thinker. It is important to integrate the objectives within chess-related lessons so that students can see the concrete connection. It is equally important to ask questions that require students to transfer skills and understanding learned in the chess context to other fields. A few examples of lessons used to enhance thinking skills in the chess program are shared below.

Thinking System

Short Term Objective:

Each student will write down the questions he/she feels are most critical for solving problems and share them with the group. Each student will adapt a meaningful checklist to help focus on pertinent problems, formulate alternate solutions, evaluate options, and decide on the best alternative.

Materials:

Demonstration board and pieces, tournament sets, Thinking Techniques List.

Instructional Method:

Students will share their ideas, questions, and techniques for solving “real” problems and chess problems. The instructor will set up positions on the demonstration board and ask the students to be **BIG** **BIG** thinkers. The students will be asked to determine what is **B**ad or **B**othersome in each position—what is the problem or problems. Pupils will determine what **I**nformation is **I**nteresting and necessary to consider to solve the problem(s). Students will look for **G**ood ideas (strengths in the position) or **G**oals to solve the problem. Finally pupils will decide on the best option or solution to the problem. The instructor will distribute the Thinking Techniques Checklist and review it with the students. Students will refer to the Thinking Techniques Checklist while playing supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the **BIG** thinking concept with them in pairs. Students will be assigned an appropriate "real life" problem to solve using the above **BIG** procedure. The process and the assignment will be reviewed and modeled over the next several lessons to insure students comprehend the technique.

Smothered Mate

Short Term Objective:

Each student will analyze two positions (See Figure 1 and Figure 2) that lead to a smothered mate and describe how they are similar and different.

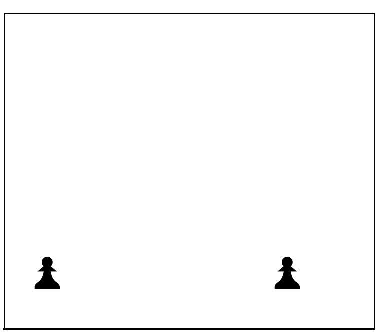
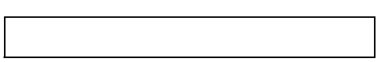


Figure 1. This example represents a smothered mate in one move.



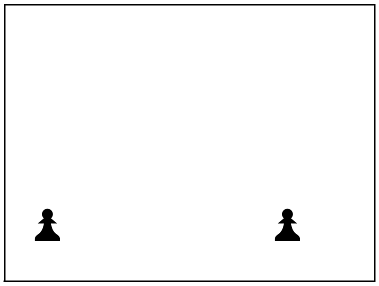


Figure 2. This example represents a smothered mate in three moves.

The student will then solve the mate.

Materials:

Demonstration board and pieces, tournament sets, Smothered Mate Quiz.

Instructional Method:

The instructor will set up positions on the demonstration board and ask the students to find the smothered mates. The group leader will invite pupils to identify facts needed to solve the problem. Given the facts, the instructor will inquire as to whether the identified facts support the student's conclusion. The teacher will ask the youngsters to explain their reasoning processes to the class. The instructor should monitor their thinking to discover if they are thinking logically in sequential steps. Students will take turns mating each other (while orally sharing thought processes with their partner) to reinforce the concept. The instructor will review a brief game on a demonstration board to model smothered mates. Students will complete the Smothered Mate Quiz and play supervised games.

Evaluation Procedures:

As the students finish their games, the instructor will review the student quizzes with them in pairs. Students must successfully solve 3 out of 4 simple problems to demonstrate competency.

Final Comments on Lessons

While it is crucial to ask thought stimulating questions that can help transfer thinking skills learned in chess to other fields, one must remember not to over do it. Keep the activities and lessons fun, but give the students the critical practice they need in applying reflective thinking processes to all aspects of their lives.

Data Collection and Recording

From 1979-81, our grant paid for a secretary who was trained to score the pre and posttests throughout the project. Because of the subjective nature of the *Torrance Tests of Creative Thinking,* I felt this was a necessary feature for the project. The secretary did not have contact with the students and therefore was not biased towards any individuals or particular treatments. She also did not know what interest areas different students had selected.

The tests were administered in accordance with the directions found in the manuals of the *Torrance Tests of Creative Thinking* and the *Watson-Glaser Critical Thinking Appraisal*. All tests were given the first week of October in 1979 (because they had not arrived on time) and then again in May of 1980. New students entering each year were given the tests in September. Alternate forms of the tests continued to be given each May. Because of the amount of time (and money) required to correct the *Torrance Tests of Creative Thinking*, it was decided to dispense with giving them after the second project year (1980-81).

For the 1986 pilot study, students' growth was measured against their tournament performances by comparing their existing USCF ratings to the ratings of their opponents and projecting a performance rating based upon their accomplishments. The SAT group took pre and posttests using the CBS Software 1985 edition of *Mastering the SAT*. Data were stored on disk and printouts of scores were maintained in the students' files.

The 1987-88 project administered the full battery of the *California Achievement Test* form E, level 16 and the *Test of Cognitive Skills*, level 3 in

September 1987. The Memory subtest and the Verbal Reasoning subtest of the *Test of Cognitive Skills* (*TCS*) was readministered on June 2, 1988. The Memory subtest score was the highest area subtest score for the class on the *TCS* when it was given in September 1987; therefore, the percentage of growth may have been limited due to the selection of this particular area (memory). The Verbal Reasoning scores on the pretest were the lowest of all subtests on the *TCS*. Several of the subjects in this experiment were considered poor readers and received remediation in reading skills.

Hypotheses to Test

Study I

This study was an empirical investigation designed to determine whether there would be a significant difference on critical and creative thinking test scores among students who study chess, students who study computer problem solving, and students who pursue other nonchess activities.

1. $ctM_a = ctM_b = ctM_c$ ***(<u>ct</u> represents critical thinking appraisal)***

    ctM_a is the gain in ***M***ean for the chess group on the thinking tests.

    ctM_b is the ***M***ean gain for the computer group on the thinking tests.

    ctM_c is the ***M***ean gain for the nonchess group on the thinking tests.

2. $crM_a = crM_b = crM_c$ ***(<u>cr</u> represents tests of creative thinking)***

    crM_a is the gain in ***M***ean for the chess group on the creativity tests.

    crM_b is the ***M***ean gain for the computer group on the creativity tests.

    crM_c is the ***M***ean gain for the nonchess group on the creativity tests.

Study II

Study II was a pilot study lasting only two months. Because of the imposed time frame and the structure of the project, no testable hypothesis was stated. This study was important because it laid the groundwork for the third study using elementary students.

Study III

This study was an empirical investigation designed to determine whether there is a significant difference on Verbal Reasoning and Memory test scores between students who study chess and the national norms of students at their grade level.

1. $mM_a = mM_b$ ***(m represents memory test)***

    mM_a is the ***M***ean for the chess group on the memory test.

    mM_b is the ***M***ean of the national norms on the memory test.

2. $vrM_a = vrM_b$ ***(vr represents verbal reasoning test)***

    vrM_a is the ***M***ean for the chess group on the reasoning test.

    vrM_b is the ***M***ean of the national norms on the reasoning test.

Statistical Analysis

The homogeneity of variance was tested using the F test. The F test evaluates the null hypothesis of no difference between the population variances (Downe and Heath, 1970, p. 183). The t test was used to test statistical significance in both experimental studies. The t test measures the quantity of the gain to assess whether it is significant.

For Study I, the chi-square test of statistical significance was used to evaluate the gains/losses on the *Watson-Glaser Critical Thinking Appraisal*. The chi-square test evaluates the significance of the number of chessplayers demonstrating gains on the *CTA* compared to the number of nonchessplayers showing gains. The chi-square test is nonparametric and insensitive to the size of gains; it considers a gain of one point in the same manner as a gain of 30 points or 100 points.

No statistical methods were employed in the pilot study between the two experimental groups because there was no common dependent variable and analysis of chess ratings compared to SAT scores is incongruous.

Study III, which was sponsored by the USA Junior Chess Olympics, used the dependent t test to evaluate gains in verbal reasoning and memory. Gains were also statistically analyzed and compared to the national norms.

Limitations

The following is a list of limitations that apply to these studies. These should be considered in interpreting the results.

Study I

1. The pretests did not arrive on time. We had already held three, and in some cases four, sessions prior to the pretesting. This could have increased the pretest scores, but at least this effect was equal for all groups.
2. All students participating in the 1979-83 research were gifted and were self-assigned to groups based on individual interest or that of their peers.
3. The creativity tests were only administered during the first two years of the project.
4. Low interscorer reliability in evaluating elaboration necessitated the exclusion of the measurement of this facet of creative thinking.
5. Some members of the computer group lost interest and subsequently did not apply themselves to the problem solving tasks with much enthusiasm.
6. No norms existed for the *Watson-Glaser Critical Thinking Appraisal* for grades seven and eight; therefore, I elected to use the ninth grade norms for comparison purposes.

7. Due to differences in difficulty on forms YM and ZM of the *Watson-Glaser Critical Thinking Appraisal*, it was necessary to use equivalent raw scores (Watson & Glaser, 1964, p. 8). This procedure may have biased results. For example, one chess student actually scored eight more problems right on his posttest than he did on his pretest; however, through the use of equivalent raw scores, he showed up as having a lower raw score on his posttest than his pretest.

8. A few individuals in the chess group did not enjoy the competitive aspect.

Study II

1. Elementary students were unable to verbalize their thought processes as well as junior high and high school students.

2. It was more difficult for the elementary age students to develop and apply the metacognitive aspects of this pilot project.

3. The two month time frame established by the Tri-State Area School Study Council proved to be a serious limitation in completing the study.

4. Discrepancy in age range was somewhat difficult to control. Students in the chess group ranged in age from 7 to 17. The SAT group's age range was 15 to 17.

5. The difference in IQ level between the SAT group and the chess group may have affected the overall validity. Students in the chess group ranged in IQ from 93 to 144, while pupils in the SAT group ranged from 130 to 146.

Study III

1. Several of the girls in the 1987-88 study did not enjoy the competitive aspect of the required chess course.

2. A few students participated only half-heartedly.

3. Several remedial readers were included in the study. The pupils lack of reading ability may have prevented them from scoring well on the Verbal Reasoning test.

Summary

To facilitate the summary of the third chapter, I elected to summarize each study separately to reduce confusion.

Study I

All subjects in the first study were gifted and were in grades 7, 8, or 9. A total of 94 completed both the pre and posttests. Students chose which activity/program they wished to participate in. Two of the most popular programs were chess and computers.

Students were pre and posttested using the *Critical Thinking Appraisal* and *Torrance's Tests of Creative Thinking*. Alternate forms of the tests were administered annually.

Students were exposed to their interest area once a week for two hours in the resource room. Some students did elect do independent study in addition to this time.

The data were statistically analyzed using the F test (to check for homogeneity of variance), the t test (to measure the quantity of gain for significance), and the chi-square test **(**to compare the number of students demonstrating growth).

Study II

Students ranged in grade from second through twelfth. Students chose between two areas: chess and SAT preparation. The chess group was very diverse, while the participants in the SAT group were quite similar.

Chess students were exposed to their interest area once a week for two hours in the resource room for gifted students. Some students did elect to do independent study in addition to this time. Students in the SAT group studied one to two hours per week using the computer and some studied manuals on their own time.

Study III

Students in this study were all sixth graders in the same self-contained classroom. The mean IQ of the class was 103. All students were required to take basically the same chess course used in the first two studies. A total of 14 pupils completed both the pre and posttests (*TCS* Memory test and Verbal Reasoning test).

Generally, students received chess lessons two or three times each week and played chess daily. Several students competed in rated chess tournaments outside of school.

Data were statistically analyzed using the dependent t test to compare students' growth in verbal reasoning and memory.

Chapter IV. Findings

The game of chess is the touchstone of the intellect. —Goethe
Age cannot wither . . . her infinite beauty. —Shakespeare

Organization of Chapter IV

To reduce confusion, I am including a discussion section specific to the experiment being reviewed at the end of the division for each of the studies.

I. Reviews the federally funded ESEA Title IV-C project (Study I).
II. Examines the Tri-State Area School Study Council pilot study (Study II).
III. Analyzes the research sponsored by the USA Junior Chess Olympics.
IV. Summarizes the findings of all three studies and highlights my interpretation of the results

Before proceeding to the maze of statistical tables, it should be noted that the descriptive statistics for all three studies were first generated using *Microsoft Works*. The t test and chi square data in the tables for the various studies were calculated manually and then checked by computer using the *Fass Statistical Analysis Program* and *HM STAT*.

Most of the tables are self-explanatory; therefore, only light notes are interspersed with the figures and tables.

Study I. ESEA Title IV-C Project Findings

It is important to note that ***all*** scores reported for the *Watson-Glaser Critical Thinking Appraisal* (*WCTA* or *CTA*) are ***equivalent*** raw scores. Watson and Glaser (1964, p. 8) used a procedure called equi-percentile equating to determine equivalent raw scores. These scores were all based on norms for high school students and beyond. Since this study tested junior high-level students and no norms existed for seventh and eighth graders, the project director was forced to use the high school norms and equivalent raw scores. In some cases, pupils in the study actually scored more correct answers on the posttest than on the pretest and still showed a loss due to the equivalent raw score procedure.

Inspection of the pre and posttest results in the figure below shows that all but one chessplayer demonstrated gains in raw scores. The average annual increase in raw scores for the chess group was 10.53.

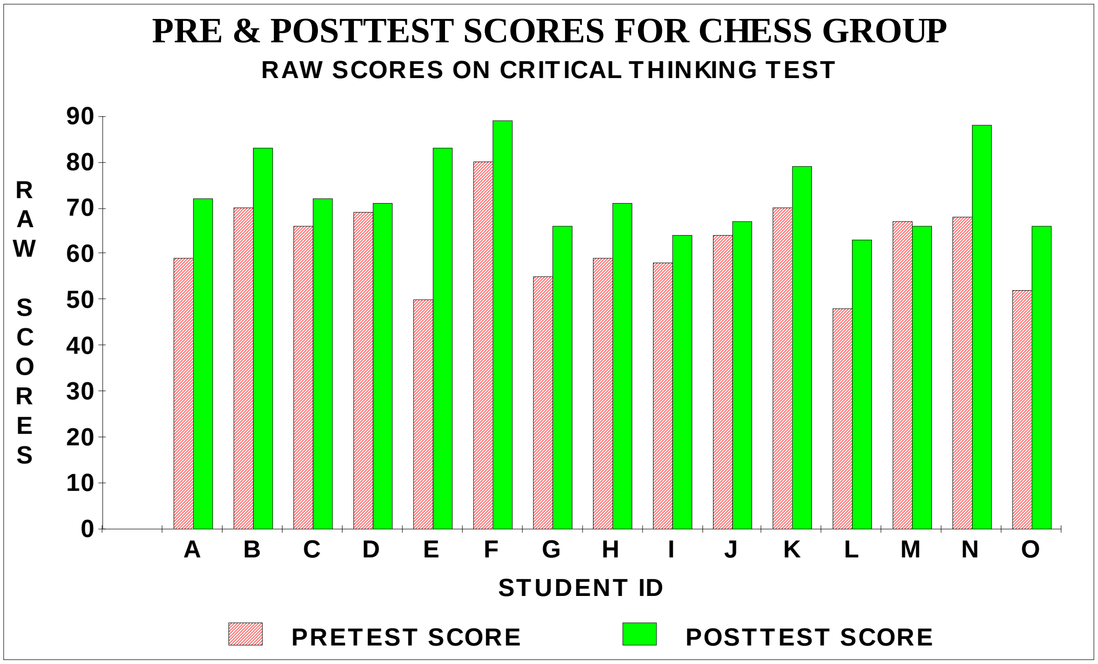


FIGURE 3. A comparison of the pre and posttest scores for the chess group on the *Critical Thinking Appraisal*

The t test was used to test statistical significance of the gains on the *Watson-Glaser Critical Thinking Appraisal*. The t test measures the quantity of the gain to assess whether it is significant.

Table 1 below demonstrates that the chessplayers achieved a very significant gain ($p < .001$) from the pretest to the posttest in critical thinking skills as measured by the *Watson-Glaser Critical Thinking Appraisal*. The level of significance suggests that there is less than one possibility in a thousand that this result could have happened by chance.

TABLE 1. Dependent t test evaluating significance of gains on the *Critical Thinking Appraisal* (*CTA*) by chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	15	62.80
Posttest Scores	15	73.33
Difference	**Standard Error**	**t value**
10.53	2.2	4.786

Significant beyond the .001 level

TABLE 2. Independent t test evaluating significance of difference on the *Watson-Glaser Critical Thinking Appraisal* between the chessplayers and nonchessplayers

VARIABLE	NUMBER	MEAN
Nonchess Group Gains	79	1.86
Chess Group Gains	15	10.53
Difference	**Standard Error**	**t value**
8.67	2.4	3.61

Significant at the .001 level

Table 2 also indicates that the chess group's performance is significantly superior to that of the nonchess group's. The results are significant at the .001

level. It appears that the chessmasters and authors quoted in Chapter II have good reason to support chess in the classroom.

TABLE 3. Independent t test evaluating significance of difference on the *Watson-Glaser Critical Thinking Appraisal* between the chess group and computer group

VARIABLE	NUMBER	MEAN
Computer Group Gains	28	1.86
Chess Group Gains	15	10.53
Difference	**Standard Error**	**t value**
8.67	2.747	3.156

Significant at the .003 level

One last group was statistically compared to the chess group using the t test: the nonparticipants. The nonparticipants were all ninth graders who scored at the 90th percentile on the *Watson-Glaser Critical Thinking Appraisal*. The nonparticipants opted not to participate in the gifted program because it was a pull-out program. If they had participated in the project, they would have missed 20% of their regular classes. The t test comparison between the chess group and nonparticipants was statistically significant at the .025 level.

The next two tables analyze the participants' data using a non-parametric, or distribution-free, test of significance. For Study I, the chi square test of statistical significance was used to evaluate the gains/losses on the *Watson-Glaser Critical Thinking Appraisal*. The chi square test evaluates the significance of the number of chessplayers demonstrating gains on the *CTA* compared to the number of nonchessplayers showing gains. Because the chi square test is nonparametric, it is insensitive to the size of gains; it considers a gain of one point in the same manner as a gain of 30 points or 100 points.

TABLE 4. Comparison of the results of chessplayers and non-chessplayers on the *Critical Thinking Appraisal*

	GAIN	NO GAIN	TOTAL
CHESS GROUP	14	1	15
NONCHESS GROUP	45	34	79
Chi Square=7.14	**Significant at the .008 level**		

Table 4 outlines a chi square analysis of the results on the *Watson-Glaser Critical Thinking Appraisal* between the chess group and the nonchess group. Of the 15 students in the chess group, 14 (93.33%) showed gains while only 45 of the 79 nonchess participants (56.96%) made gains.

TABLE 5. Comparison of the results of the chess group and the computer group on the *Critical Thinking Appraisal*

	GAIN	NO GAIN	TOTAL
CHESS GROUP	14	1	15
COMPUTER GROUP	15	13	28
Chi Square=7.03	**Significant at the .008 level**		

Table 5 reviews a chi square analysis of the results on the *Watson-Glaser Critical Thinking Appraisal* between the chess group and the computer group.

Of the 15 students in the chess group, 14 (93.33%) showed gains while only 15 of the 28 (53.57%) members of the computer group made gains. An additional test (not illustrated) comparing the chess group to the nonparticipants resulted in a chi square value of 10.58, which was statistically significant at the .002 level.

TABLE 6. Summary of the results on the *WCTA* for participants in the chess, computer, and nonchess groups

PROJECT PARTICIPANTS	Nonchess	Computer	Chess
Mean for Pretest	60.29	60.71	62.80
Mean for Posttest	62.15	62.57	73.33
Gain or Loss	1.86	1.86	10.53

TABLE 7. Dependent t test evaluating significance of gains on the *CTA* by male chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	11	62.82
Posttest Scores	11	74.00
Difference	**Standard Error**	**t value**
11.18	2.9	3.851

Significant at the .003 level

Table 8 also demonstrates a statistical significance in favor of the males in the chess group over the males in the nonchess group. The males in the nonchess group and the males in the chess group both have higher mean scores than the mean scores for the combined males and females presented earlier.

TABLE 8. Independent t test evaluating significance of difference on the *Watson-Glaser Critical Thinking Appraisal* between the male chessplayers and nonchessplayers

VARIABLE	NUMBER	MEAN
Nonchess Group Gains	30	2.967
Chess Group Gains	11	11.182
Difference	**Standard Error**	**t value**
8.215	2.599	3.16

Significant at the .005 level

TABLE 9. Independent t test evaluating significance of difference on the *Watson-Glaser Critical Thinking Appraisal* between the males in the chess group and computer group

VARIABLE	NUMBER	MEAN
Computer Group Gains	9	1.00
Chess Group Gains	11	11.18
Difference	**Standard Error**	**t value**
10.18	3.894	2.614

Significant at the .017 level

TABLE 10. Comparison of the results on the *WCTA* for males in the chess and nonchess groups

	GAIN	NO GAIN	TOTAL
CHESS GROUP	10	1	11
NONCHESS GROUP	18	12	30

Chi Square=3.55 Significant at .056 level

TABLE 11. Comparison of the results on the *WCTA* for males in the chess and computer groups

	GAIN	LOSS	TOTAL
CHESS GROUP	10	1	11
COMPUTER GROUP	4	5	9

Chi Square=5.09 Significant at the .023 level

While Table 11 illustrates a significant difference between males in the chess group and the computer group, the level of significance is not so great as that noted in the earlier tables, which included the females.

TABLE 12. Summary of the results on the *WCTA* for males in the chess, computer, and nonchess groups

PROJECT PARTICIPANTS	Nonchess	Computer	Chess
Mean for Pretest	60.30	61.22	62.82
Mean for Posttest	63.27	62.22	74.00
Gain or Loss	2.97	1.00	11.18

In this segment of tables comparing the males of the different groups, the gains are not quite so significant as in the first section of tables, which compared the gains of all students. In the next division of tables, the females in the chess group are compared to the females in the nonchess and computer groups. Since the female chessplayers' gains were less than the males, it is possible to predict that their comparisons will not be as significant.

TABLE 13. Dependent t test evaluating significance of gains on the *CTA* by female chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	4	62.75
Posttest Scores	4	71.50
Difference	**Standard Error**	**t value**
8.75	2.529	3.46

Significant at the .043 level

TABLE 14. Independent t test evaluating significance of difference on the *Watson-Glaser Critical Thinking Appraisal* between the female chessplayers and nonchessplayers

VARIABLE	NUMBER	MEAN
Nonchess Group Gains	48	1.02
Chess Group Gains	4	8.75
Difference	**Standard Error**	**t value**
7.73	4.457	1.734

Approaches Significance at the .085 level

Although there were only four females in the chess group, the dependent t test (Table 13) still demonstrates a significant gain. The sample size is too small to show significance in the other comparisons.

TABLE 15. Independent t test evaluating significance of difference on the *Watson-Glaser Critical Thinking Appraisal* between the females in the chess group and computer group

VARIABLE	NUMBER	MEAN
Computer Group Gains	19	2.27
Chess Group Gains	4	8.75
Difference	**Standard Error**	**t value**
6.48	4.868	1.331

Lacks significance at the .195 level

TABLE 16. Comparison of the results on the *WCTA* for females in the chess, computer, and nonchess groups

PROJECT PARTICIPANTS	Nonchess	Computer	Chess
Mean for Pretest	60.35	60.47	62.75
Mean for Posttest	61.37	62.74	71.50
Gain or Loss	1.02	2.27	8.75

The next series of tables comparing the gains of the eighth graders on the *CTA* are perhaps the most important of all the critical thinking results. Eighth graders comprised 46% of the total number of students participating in the project designed to develop thinking skills. Out of a total of ninety-four pupils who completed both the pre and posttests, forty-three were eighth graders. Because this was the largest grade sample, it becomes more statistically important and increases the level of confidence in the results.

TABLE 17. Dependent t test evaluating significance of gains on the *CTA* by 8th grade chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	12	62.08
Posttest Scores	12	72.92
Difference	**Standard Error**	**t value**
10.84	2.743	3.952

Significant at the .003 level

TABLE 18. Independent t test evaluating significance of difference on the *Watson-Glaser Critical Thinking Appraisal* between the 8th grade chessplayers and nonchessplayers

VARIABLE	NUMBER	MEAN
Nonchess Group Gains	31	1.258
Chess Group Gains	12	10.840
Difference	**Standard Error**	**t value**
9.582	3.284	2.918

Significant at the .006 level

TABLE 19. Independent t test evaluating significance of difference on the *Watson-Glaser Critical Thinking Appraisal* between the 8th graders in the chess group and computer group

VARIABLE	**NUMBER**	**MEAN**
Computer Group Gains	9	4.55
Chess Group Gains	12	10.84
Difference	**Standard Error**	**t value**
6.29	4.14	1.519

Lacks Significance at the .142 level

TABLE 20. Comparison of the results on the *WCTA* for 8th graders in the chess and nonchess groups

	GAIN	**LOSS**	**TOTAL**
CHESS GROUP	11	1	12
NONCHESS GROUP	15	16	29

Chi Square=6.78 **Significant at the .009 level**

Table 20 compares the number of chess students and nonchess students who increased or decreased their scores on the *Watson-Glaser Critical Thinking Appraisal*. This table shows that the eighth graders participating in the chess program made significant gains ($p < .015$) over their peers who selected alternate activities.

TABLE 21. Comparison of the results on the *WCTA* for 8th graders in the chess, computer, and nonchess groups

PROJECT PARTICIPANTS	Nonchess	Computer	Chess
Mean for Pretest	60.00	60.56	62.08
Mean for Posttest	61.26	65.11	72.92
Gain or Loss	1.26	4.55	10.84

The eighth grade computer group's gain appears meaningful; however, it lacks significance at the .174 level. Only the chess group managed to achieve a statistically significant result on the dependent t test.

TABLE 22. Review of the results of chessplayers and nonchessplayers by grade level on the *Critical Thinking Appraisal*

CHESS PARTICIPANTS	Grade 7	Grade 8	Grade 9
Mean for Pretest	58.50	62.08	80.00
Mean for Posttest	68.00	72.92	89.00
Gain or Loss	9.50	10.84	9.00
NONCHESS PARTICIPANTS			
Mean for Pretest	58.65	60.00	62.25
Mean for Posttest	59.27	61.26	68.31
Gain or Loss	.62	1.26	6.06
DIFFERENCE (Chess - Nonchess)	8.88	9.58	2.94

As the project director anticipated, pretest and posttest mean scores are higher for the students in the higher grades. By referring to the above table, it is easy to see that the chess group at all grade levels outdistanced the nonchess participants. The smallest gain was achieved by the ninth graders because of the large difference in pretest means. Due to the small sample size at some grade levels, it was not practicable to perform statistical analyses to demonstrate the level of significance.

TABLE 23. Review of the results of project participants compared with the nonparticipants on the *Critical Thinking Appraisal*

PROJECT PARTICIPANTS	Nonchess	Computer	Chess
Mean for Pretest	60.29	60.71	62.80
Mean for Posttest	62.15	62.57	73.33
Gain or Loss	1.86	1.86	10.53
NONPARTICIPANTS*			
Mean for Pretest	72	72	72
Mean for Posttest	67	67	67
Gain or Loss	-5	-5	-5
DIFFERENCE	6.86	6.86	15.53

*All nonparticipants were ninth graders scoring at the 90th percentile.

Of all the groups tested, only the nonparticipants experienced regression, but they also had the highest entry level scores on the *CTA* pretest (with the exception of the ninth grade chess group). Because of the small sample size, the results for the nonparticipants do not seem substantial. The project director would recommend replication of this study using a control group of nonparticipants.

TABLE 24. Statistical summary for *CTA* (Expanded tables are available for most of the probabilities listed below. Refer to the list of tables for information.)

TABLES	t Test *p*<	Chi Square X^2 *p*<
MALES & FEMALES COMBINED:		
Chess Group	0.001	
Chess vs. Nonchess	0.001	0.008
Chess vs. Computer	0.003	0.008
Chess vs. Nonparticipants	0.025	0.002
MALES:		
Chess Group	0.003	
Chess vs. Nonchess	0.072	0.056
Chess vs. Computer	0.017	0.023
FEMALES:		
Chess Group	0.043	
Chess vs. Nonchess	0.085	0.071
Chess vs. Computer	0.195	0.104
ALL 8TH GRADERS:		
Chess Group	0.003	
Chess vs. Nonchess	0.006	0.009
Chess vs. Computer	0.142	0.05

This concludes the critical thinking data for Study I. The next series of tables and figures will graphically illustrate the gains in different aspects of creativity tested in this research: fluency, flexibility, and originality.

Verbal fluency is an individual's ability to generate a large number of ideas with words. Chessplayers often have a running dialogue within their minds reviewing the checklist for important strategic and tactical factors or mentally calculating, “If I go there, then he'll move to . . .”

Flexibility represents a person's ability to produce a variety of types of ideas, to shift from one approach to another, or to use a variety of strategies. Originality is skill at producing ideas that are different from the obvious.

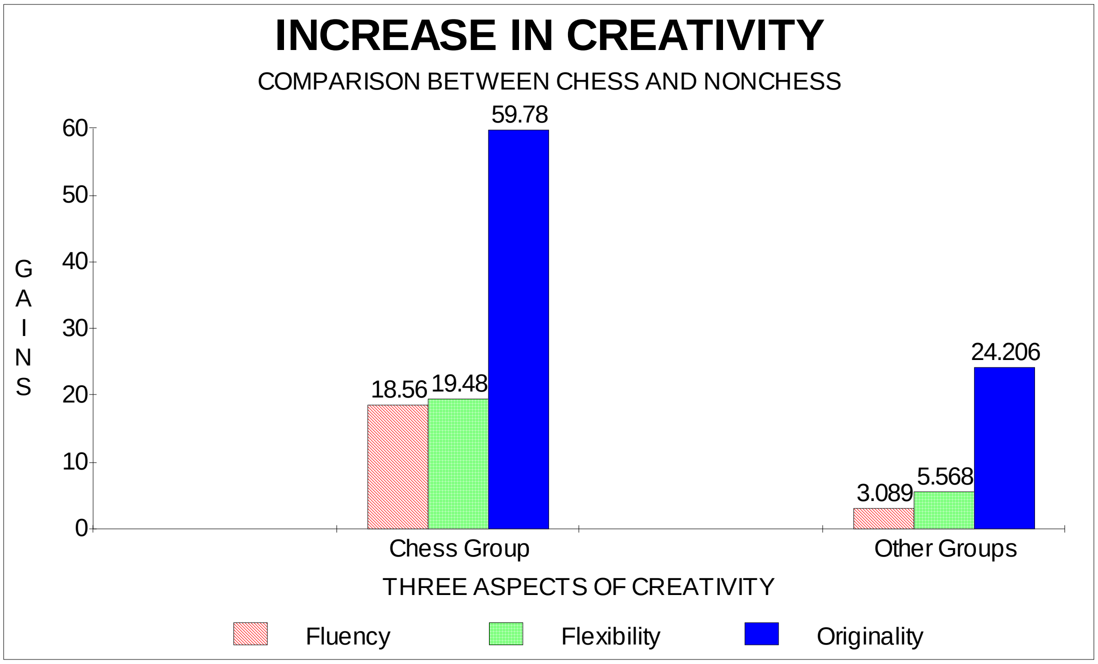


FIGURE 4. A comparison of the chess group gains to the nonchess group gains

It is important to note that ***all*** scores reported for the *Torrance Tests of Creative Thinking* are standard T-scores. All raw scores were converted in accordance with the recommendations in the *Torrance Tests of Creative Thinking Norms-Technical Manual* (1974, pp. 48, 56). These scores were all based on creative thinking norms established for junior high school students.

Torrance (1974) defined creative thinking as "a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies: testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results."

Creativity is a major aspect of chess at the master level, but can chess influence creativity at the amateur level? The following tables shed some light on this question.

TABLE 25. Dependent t test evaluating significance of gains on the *Torrance Tests of Creative Thinking* for fluency by the chessplayers

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Pretest Scores	21.619	65.50
Posttest Scores	7.698	84.06
Difference	**Standard Error**	**t value**
18.56	7.86	2.36
Marginally Significant at .077 level		

It should be noted that several researchers have found that gains in originality are typical for those receiving creativity training, whereas gains in *fluency* are *often slight or nonexistent*. In light of this research, the fact that the chess group's gains in fluency approached significance at the .077 level on the dependent t test appears important. (The small sample size of the chess group is a serious limitation to determining the actual impact of chess on creative thinking.) The fact that the chess group's gains in fluency were significant beyond the .05 level when compared to the national norms is an even more important discovery.

It appears that chess is superior to many existing programs for developing creative thinking and, therefore, could logically be included in a differentiated program for mentally gifted students.

TABLE 26. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for fluency between the chessplayers and nonchessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Nonchess Group Gains	15.134	3.089
Chess Group Gains	15.729	18.560
Difference	**Standard Error**	**t value**
15.471	7.628	2.028

Significant at the .049 level

TABLE 27. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for fluency between the chess group and computer group

VARIABLE	STANDARD DEVIATION	MEAN
Nonchess Group Gains	9.228	6.042
Chess Group Gains	15.729	18.560
Difference	**Standard Error**	**t value**
12.518	5.726	2.186

Significant at the .038 level

TABLE 28. Dependent t test evaluating significance of gains on the *Torrance Tests of Creative Thinking* for fluency by the male chessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Pretest Scores	24.17	65.50
Posttest Scores	8.09	85.38
Difference	**Standard Error**	**t value**
19.88	9.99	1.99

Lacks Significance at .142 level

TABLE 29. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for fluency between the male chessplayers and male nonchessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Nonchess Group Gains	6.195	3.311
Chess Group Gains	17.338	19.875
Difference	**Standard Error**	**t value**
16.564	7.127	2.324

Significant at the .039 level

TABLE 30. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for fluency between the males in the chess group and the computer group

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Computer Group Gains	6.746	2.200
Chess Group Gains	17.338	19.875
Difference	**Standard Error**	**t value**
17.675	8.767	2.016

Marginally Significant at the .076 level

TABLE 31. Dependent t test evaluating significance of gains on the *Torrance Tests of Creative Thinking* for flexibility by chessplayers

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Pretest Scores	10.80	52.86
Posttest Scores	8.06	72.34
Difference	**Standard Error**	**t value**
19.48	5.466	3.564

Significant at the .024 level

TABLE 32. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for flexibility between the chessplayers and nonchessplayers

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Nonchess Group Gains	15.33	5.568
Chess Group Gains	10.93	19.480
Difference	**Standard Error**	**t value**
13.912	6.21	2.24

Significant at the .05 level

TABLE 33. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for flexibility between the chess group and computer group

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Computer Group Gains	10.37	9.495
Chess Group Gains	10.93	19.480
Difference	**Standard Error**	**t value**
9.985	5.507	1.813

Approaches Significance at the .08 level

TABLE 34. Dependent t test evaluating significance of gains on the *Torrance Tests of Creative Thinking* for flexibility by male chessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Pretest Scores	8.98	49.25
Posttest Scores	8.985	72.025
Difference	**Standard Error**	**t value**
22.775	5.63	4.045

Significant at the .03 level

TABLE 35. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for flexibility between the male chessplayers and male nonchessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Nonchess Group Gains	8.167	3.811
Chess Group Gains	9.751	22.775
Difference	**Standard Error**	**t value**
18.964	5.674	3.342

Significant at the .007 level

TABLE 36. Independent t test evaluating significance of gains on the *Torrance Tests of Creative Thinking* for flexibility between the males in the chess group and the computer group

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Nonchess Group Gains	6.951	5.417
Chess Group Gains	9.751	22.775
Difference	**Standard Error**	**t value**
17.358	5.908	2.938

Significant at the .018 level

TABLE 37. Dependent t test evaluating significance of gains on the *Torrance Tests of Creative Thinking* for originality by chessplayers

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Pretest Scores	19.42	74.24
Posttest Scores	17.23	134.02
Difference	**Standard Error**	**t value**
59.78	12.98	4.606

Significant at the .01 level

TABLE 38. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for originality between the chessplayers and nonchessplayers

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Nonchess Group Gains	28.707	24.206
Chess Group Gains	28.835	59.780
Difference	**Standard Error**	**t value**
35.574	14.39	2.472

Significant at the .018 level

TABLE 39. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for originality between the chess group and computer group

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Computer Group Gains	16.037	34.826
Chess Group Gains	28.835	59.780
Difference	**Standard Error**	**t value**
24.954	10.198	2.447

Significant at the .022 level

TABLE 40. Dependent t test evaluating significance of gains on the *Torrance Tests of Creative Thinking* for originality by male chessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Pretest Scores	19.532	70.0
Posttest Scores	13.649	140.1
Difference	**Standard Error**	**t value**
70.1	13.027	5.381

Significant at the .016 level

TABLE 41. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for originality between the male chessplayers and male nonchessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Nonchess Group Gains	18.696	17.022
Chess Group Gains	22.581	69.950
Difference	**Standard Error**	**t value**
52.928	13.046	4.057

Significant at the .002 level

TABLE 42. Independent t test evaluating significance of difference on the *Torrance Tests of Creative Thinking* for originality between the males in the chess and the computer groups

VARIABLE	STANDARD DEVIATION	MEAN
Nonchess Group Gains	12.378	25.083
Chess Group Gains	22.581	70.100
Difference	**Standard Error**	**t value**
45.017	12.408	3.628

Significant at the .007 level

TABLE 43. Review of the results of chessplayers and nonchessplayers by grade level on the *Torrance Tests of Creative Thinking*

CHESS PARTICIPANTS	Fluency	Flexibility	Originality
7th grade gains*	13.3	6.3	18.5
8th grade gains	18.4	24.63	81.67
9th grade gains	24.3	17.2	34.8
NONCHESS PARTICIPANTS			
7th grade gains	2.93	7.09	30.33
8th grade gains	6.48	4.53	22.23
9th grade gains	-2.53	5.4	19.71
DIFFERENCE (CHESS GROUP - NONCHESS GROUP)			
7th grade gains*	10.37	-0.79	-11.83
8th grade gains	11.92	20.1	59.44
9th grade gains	26.83	11.8	15.09

**Only one chess student in the seventh grade completed both the pre and posttest.*

Discounting the lone seventh grader in the chess group to complete both pre and posttests, the chess group consistently outscored the nonchess students. The average gain (among all three types of creativity measured) for the chess group over the nonchess group in eighth and ninth grades was 24.197.

TABLE 44. Review of the results of the chess and computer groups by grade level on the *Torrance Tests of Creative Thinking*

CHESS GROUP	**Fluency**	**Flexibility**	**Originality**
7th grade gains*	13.3	6.3	18.5
8th grade gains	18.4	24.63	81.67
9th grade gains	24.3	17.2	34.8
COMPUTER GROUP			
7th grade gains	2.93	7.09	30.33
8th grade gains	12.42	8.07	20.08
9th grade gains	5.26	12.52	38.48
DIFFERENCE (CHESS GROUP - COMPUTER GROUP)			
7th grade gains*	10.37	-0.79	-11.83
8th grade gains	5.98	16.56	42.41
9th grade gains	19.04	4.68	-3.68

**Only one chess student in the seventh grade completed both the pre and posttest.*

Disregarding the lone seventh grader in the chess group to complete both pre and posttests, the chess group consistently outscored the computer students; however, the average gain for the chess group over the computer group in eighth and ninth grades was only 14.17 or about ten points less than the comparison in Table 43.

TABLE 45. Review of the results of participants and nonparticipants on the *Torrance Tests of Creative Thinking*

ALL GIFTED PUPILS	Fluency	Flexibility	Originality
chess group gains	18.560	19.480	59.780
nonchess group gains	3.089	5.568	24.206
computer group gains	6.042	9.495	34.826
nonparticipants' gains	.030	2.300	31.900

TABLE 46. Review of the results of females participating in the project on the *Torrance Tests of Creative Thinking*

FEMALE PARTICIPANTS	Fluency	Flexibility	Originality
chess group gains*	13.30	6.30	18.50
nonchess group gains	2.98	6.40	27.61
computer group gains	7.82	11.38	39.32

**Only one female chess student completed both the pre and posttest.*

Due to the lone female seventh grader in the chess group completing both pre and posttests, the results are inconclusive; however, the females in the computer group demonstrated consistent growth in all three areas of creativity measured.

The mean norms used for comparison with the chess group on the independent t test in Table 47 below were taken from Table 19, page 51 of the *Norms-Technical Manual* for the *Torrance Tests of Creative Thinking* by Dr. E. Paul Torrance (1974). The normative data for seventh, eighth, and ninth graders listed in Table 19 of the manual were interpolated to augment the statistical analysis.

TABLE 47. Statistical Summary of t Tests on Creativity (*Expanded tables are not available for the 8th grade probabilities listed below.*)

STATISTICAL COMPARISONS	FLUENCY *p<*	FLEXIBILITY *p<*	ORIGINALITY *p<*
MALES & FEMALES COMBINED:			
Dependent Chess	0.077	0.024	0.01
Population Mean Chess vs. Norms	0.039	0.002	0.001
Independent Chess vs. Nonchess	0.049	0.05	0.018
Independent Chess vs. Computer	0.038	0.08	0.022
ALL MALES:			
Dependent Chess	0.142	0.03	0.016
Population Mean Chess vs. Norms	0.07	0.008	0.003
Independent Chess vs. Nonchess	0.039	0.007	0.002
Independent Chess vs. Computer	0.076	0.018	0.007
ALL 8TH GRADERS:			
Dependent Chess	0.32	0.088	0.018
Population Mean Chess vs. Norms	0.171	0.037	0.019
Independent Chess vs. Nonchess	0.305	0.061	0.009
Independent Chess vs. Computer	0.606	0.12	0.027
ALL 8TH GRADE MALES:			
Dependent Chess	0.32	0.088	0.018
Population Mean Chess vs. Norms	0.171	0.037	0.019
Independent Chess vs. Nonchess	0.383	0.014	0.006
Independent Chess vs. Computer	0.561	0.107	0.02

Discussion of the Findings for Study I

I have provided the necessary data in the above tables and figures to answer the questions posed in Chapter I and to test the null hypotheses stated in Chapter III.

Null Hypotheses

1. $\boldsymbol{ctM_a = ctM_b = ctM_c}$ ***(<u>ct</u> represents critical thinking appraisal)***

ctM_a is the gain in ***M***ean for the chess group on the thinking tests.

ctM_b is the ***M***ean gain for the computer group on the thinking tests.

ctM_c is the ***M***ean gain for the nonchess group on the thinking tests.

Based on the data collected and listed in Table 8 and others:

$ctM_a = 10.53$

$ctM_b = 1.86$

$ctM_c = 1.86$

it is possible to reject the first null hypothesis at the 99% confidence level.

2. $\boldsymbol{crM_a = crM_b = crM_c}$ ***(<u>cr</u> represents tests of creative thinking)***

crM_a is the gain in ***M***ean for the chess group on the creativity tests.

crM_b is the ***M***ean gain for the computer group on the creativity tests.

crM_c is the ***M***ean gain for the nonchess group on the creativity tests.

Based on the data in Figure 4 and others the average creativity scores are:

$crM_a = 32.61$

$crM_b = 16.79$

$crM_c = 10.95$

it is possible to reject the second null hypothesis at the 95% confidence level.

It is important that the reader keep in mind that the computer group was a subset of the nonchess group. The computer group had the largest sample size of any of the subgroups, and, therefore, provided a valuable comparison treatment group for this study.

Questions on Critical Thinking

1. Can chess—as the chessmasters assume—enhance critical thinking skills?

Yes, the chess group achieved greater gains overall and within all subsets evaluated.

2. Can a chess course enhance critical thinking more than a computer problem *solving course; will they prove equally effective; or will the computer course demonstrate superiority?* The chess group far outdistanced all the other groups; however, in one evaluation of subsets for eighth graders the computer group managed to score a gain of 41.9% of what the eighth graders in the chess group achieved.

3. Will the nonchess treatment group surpass the chess group? As the tables point out, the chess group's gains in comparison to the nonchess treatment group were very significant at the .001 level.

4. How will gifted students who do not participate in the reflective thinking development project compare to those who do? Interestingly, a few ninth graders, who scored at the 90th percentile on the *CTA* pretest, chose not to participate in the thinking development program. This provided a control group that received no treatment in the gifted resource room. This group showed regression, which seems to indicate that the thinking development program did offer some degree of stimulation over the regular classroom.

Questions on Creative Thinking

1. Can chess enhance creative thinking skills? It would appear from the data collected and the statistical test results listed in the above tables that there can be little doubt of this. Dr. Stephen Schiff's claim that creativity can be taught through the art of chess has been proven.

2. Can a chess course enhance creativity more than a computer problem solving course; will they prove equally effective; or will problem solving with the computer test superior? While the computer group made definite gains, the chess group surpassed all other treatment groups in the test results.

3. Will the nonchess treatment group surpass the chess group? No, this has been irrefutably established in the preceding tables.

4. Will chess improve certain aspects of creativity more than computer problem *solving?* While the entire chess group made superior gains over the computer group in all three areas, the aspect that demonstrated the most significant growth was originality. It should be noted once again that several researchers have found that gains in originality are the norm for those receiving creativity training, whereas gains in fluency are often slight or nonexistent. The fact that the chess group's gains in fluency were significant beyond the .05 when compared to the national norms is an important discovery.

5. Which types of creative thinking will be increased more by computer problem solving and which will be better enhanced by chess problem solving? The computer group did not outscore the chess group in any aspect of creativity or within any subset studied and evaluated in the above tables.

6. How will students who do not participate in the thinking development project compare to those who do? The results have been tabulated in Table 45. The nonparticipants' increases in fluency were .30, or, stated in comparison to the chess group's gains, the nonparticipants' gains were only 1.6% of the chess group's. The nonparticipants scored 11.8% as much as the chess group in flexibility, whereas in originality the nonparticipants scored 53.36% of what the chess group achieved. Nonparticipants clearly lagged behind the other groups in fluency and flexibility, but their originality gains were greater than those of the nonchess group and only slightly lower than the computer group's.

Why Has Chess Improved Thinking Skills More than Other Programs?

The following brief answers are summarized from the 1986 edition of my book, the *USA Junior Chess Olympics Training Manual*:

> a. Chess provides more problems with more possible solutions than most activities. After only three moves, there are about 64 million possible alternative solutions. Chess requires less time to "solve" a problem than thinking programs, e.g. Torrance's Future Problem Solving. Thus students have more time to practice solving problems

and to practice developing, evaluating, revising, and using "their system" for solving problems.
b. Many traditional courses do not allow for creativity. In the rush to cover the material, there simply is not enough time to allow students to think creatively, so they are not encouraged to think original thoughts. In chess, while some basic rules and patterns are taught, the focus is placed on application rather than rote memorization, thus encouraging originality.
c. Many thinking development programs are not socio-culturally appropriate. The best intentions in a program may be thwarted if students cannot relate it to their cognitive structures and to the world they live in. Chess transcends these barriers.
d. In the *USA Junior Chess Olympics Program*, students are taught and encouraged to think verbally, visually, and kinesthetically. Chess accommodates all thinking and learning styles.

It is evident from the above tables and data that chess had a definite impact on developing both critical and creative thinking skills. Because the sample size of the treatment group was only 15 students, I would encourage replication of this study using a larger *N*.

It was also evident that there were significant gains in the participants' chess skills. Six of the pupils involved in this study participated in the annual Pennsylvania State Scholastic Championship beginning in 1980. Three of those six excelled. Two of the boys became candidate masters and one of the girls made the top 50 list for all women chessplayers in the United States.

I concur wholeheartedly with Dr. Stephen M. Schiff (1991), who wrote: ". . . the study of chess is one of the most critically important additions to the curriculum that schools can offer to our pre-adolescent gifted and talented student population." Based on the results of Study I and numerous others with similar results, I ***urge*** the inclusion of chess in the curriculum to augment the skills of the mentally gifted.

Study II. Tri-State Area School Pilot Project Findings

This study focused on developing a personalized thinking system. Mentally gifted students at Bradford Area High School in grades 10-12 self-selected one of two options: SAT preparation or chess. An equal number of nongifted pupils in grades 9-10 participated in the chess treatment. Both treatments demonstrated short term gains that were statistically significant (SAT $p < .024$; chess $p < .004$).

TABLE 48. Review of the gains by both gifted and nongifted chess-players after pilot study

GIFTED STUDENTS	MEAN
Official Pre-Rating	1498
Performance Rating at States	1637
Short Term Unofficial Gain	139
Official Post-Rating one year later	1577
Long Term Official Gain	79
NONGIFTED STUDENTS	**MEAN**
Official Pre-Rating	1279
Performance Rating at States	1626
Short Term Unofficial Gain	347
Official Post-Rating one year later	1357
Long Term Official Gain	78
DIFFERENCE (GIFTED - NONGIFTED STUDENTS)	
Short Term Unofficial Gain	-208
Long Term Official Gain	1

Table 48 above compares an equal number of nongifted students in grades nine and ten with gifted students in tenth through twelfth grade. There were no nongifted students participating in the higher grades. All students were exposed to a systematic thinking development program for nearly two months prior to the Pennsylvania State Scholastic Championship. The unofficial performance ratings were collected based upon all students performances at the State

Championship. The unofficial gain by the gifted students was 139, but the unofficial gain by the nongifted students was 347. While the short term unofficial gain by the nongifted students is over 27%, the gifted students short term gain was only a little more than 9%. When the short term performance gains of the nongifted group are compared statistically to the gains of the gifted group using the independent t test, the difference is significant at the 0.009 level.

Official long term gains of both groups were calculated using the annual *USCF Rating Lists*. The official gains are nearly identical. The percentage of increase for the long term gain was only slightly larger (less than 1%) for the nongifted than for the gifted students.

TABLE 49. Dependent t test evaluating significance of gains in the *official ratings* by all chessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Pretest Scores	264.94	1388.5
Posttest Scores	314.64	1467.0
Difference	**Standard Error**	**t value**
78.5	31.73	2.474

Significant at the .055 level

Table 50 and 51, respectively, represent the dependent gains made by the chess group and the gifted students after two months of participating in the project. The scores are based on the computerized practice tests using the CBS software *Mastering the SAT*. The short term gains appear meaningful. Using a related t test verified that the gain is significant at the .024 level. No records were obtained for scores on the actual SAT.

TABLE 50. Dependent t test evaluating significance of gains in the *performance ratings* (short term gains) **by <u>all</u> chessplayers**

VARIABLE	STANDARD DEVIATION	MEAN
Pretest Scores	264.94	1388.5
Posttest Scores	236.13	1631.5
Difference	**Standard Error**	**t value**
243	46.507	5.225
Significant at the .004 level		

TABLE 51. Review of the gain by the gifted students in the SAT group

GIFTED STUDENTS	MEAN
Pretest Score on SAT	1085
Posttest Score on SAT	1114
Gain	29

Discussion of the Findings for Study II

The unofficial (*performance*) gain by the gifted students was 139, while the unofficial gain by the nongifted students was 347. Considering the difference in grade levels, this seems to be significant; however, some knowledge of the Swiss System is essential. Briefly, the Swiss System is a method of pairing players in which the lower rated players are paired against the higher rated in the early rounds. Because the nongifted students were lower rated, they were paired up earlier than the gifted students with higher ratings. This accounts for part of the difference but not all of it.

It is inappropriate to compare the SAT group to the chess groups; however, it is worth noting the percentage of gain earned by each of the three groups during the short term study. The SAT group (comprised of gifted students in grades 10-12) increased 2.67% from the pretest score; the gifted students in the chess group gained 9.27%; the greatest gain (27.13%) was realized by the nongifted pupils in the chess group.

It would appear from this very short two month study that it is possible to enhance achievement by focusing on individual student's modality strengths, creating an individualized thinking plan, analyzing and reflecting upon one's own problem solving processes, sharing his/her thinking system with peers, and modifying the system to integrate other modalities.

While caution should be used in interpreting this pilot study, it seems that because the chess group demonstrated both a larger quantity of gain and a greater significance in its short term gain than the SAT group, it is plausible that chess may enhance these skills at a faster rate than SAT preparation.

Study III. USA Junior Chess Olympics Research Findings

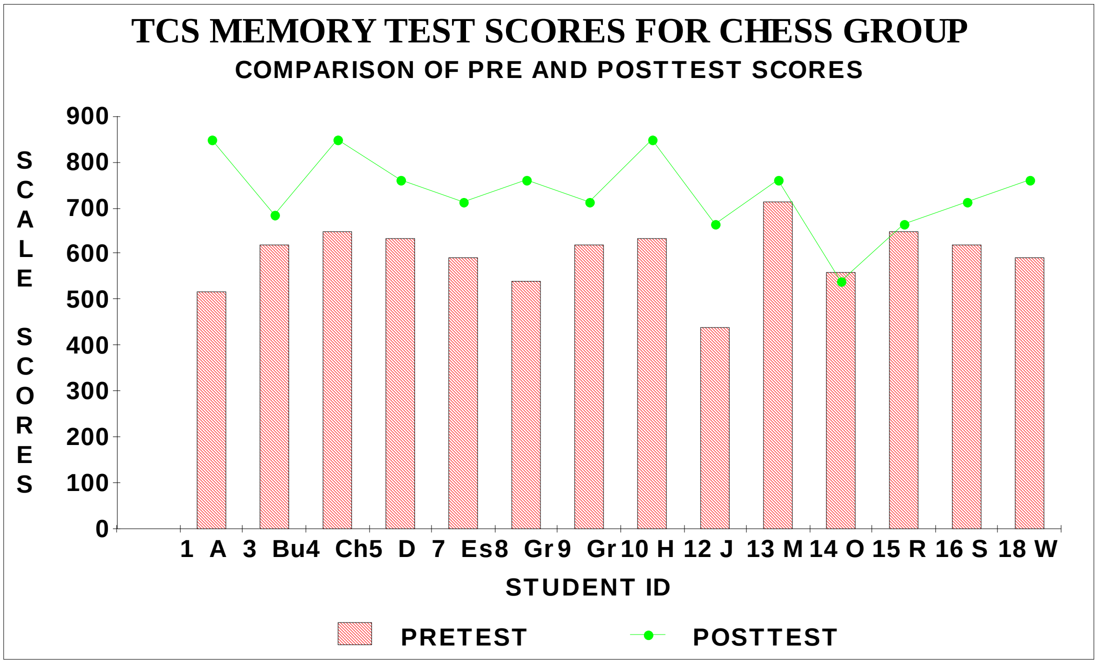


FIGURE 5. Comparison of pretest and posttest scores on the *Test of Cognitive Skills* Memory test

All scores reported for the *Test of Cognitive Skills* are listed as ***scale scores***. Scores have been converted from number correct scores to scale scores using conversion Table 3 in the *TCS Norms Book* for level 3. According to the *Norms Book*, "The scale score is the basic score for *TCS*. This score is especially appropriate for research studies and statistical analyses . . ." (1981, p. 7).

Table 52 on the next page shows the Memory test scores from the beginning of the school year and the end. These scores, as noted earlier, have been changed from number correct scores to scale scores using conversion Table 3 in the *TCS Norms Book.*

TABLE 52. *TCS* Memory test scores

ID #	PRETEST	POSTTEST	GAIN OR LOSS
1	517	849	332
3	619	685	66
4	648	849	201
5	633	761	128
7	591	713	122
8	540	665	125
9	619	713	94
10	633	849	216
12	439	665	226
13	713	761	48
14	559	540	-19
15	648	665	17
16	619	713	94
18	591	761	170

TOTAL PRETEST:	8369
AVERAGE PRETEST:	597.7857143
STANDARD DEVIATION OF PRETEST:	64.81972646
TOTAL POSTTEST:	10189
AVERAGE POSTTEST:	727.7857143
STANDARD DEVIATION OF POSTTEST:	83.22274635
TOTAL GAIN OR LOSS:	1820
AVERAGE GAIN OR LOSS:	130

As listed in the *TCS Technical Report* (1983), the mean scale score on the Memory test for sixth graders across the nation is 591. The pretest mean score for the sixth grade students in this study scored an average of 597.786. Based on the F-test, there is no significant difference between the variance of the norms and the variance of the test group.

The posttest scale scores averaged 727.786 for an average gain of 130 points. Inspection of the scores in the above table shows that all but one student demonstrated a gain. By using Table 6 in the Norms Book, the project director calculated the mean pre and post percentile ranks to be 59% and 91%, respectively, for a gain of 32%. This increased percentile score indicates an **above average** performance.

An ***average*** student in the sixth grade scores at the 50th percentile on the subtests of the *TCS*. If the student continues to grow in proficiency at an average rate throughout the year, that student will again score at the 50th percentile in seventh grade. Considering that no percentile gain is the norm, the chess group's gain of 32 in percentile score appears significant.

Because percentile scores are considered inappropriate for statistical analysis, I used the scale scores to perform the t test. The obtained t = 5.927, which is statistically significant beyond the .001 level. Even when I compared the sixth graders' posttest results to those of the seventh grade norms, the t test resulted in an obtained t = 5.49, which is statistically significant beyond the .001 level.

The next three tables review the treatment group's gains and indicate their level of significance.

TABLE 53. Dependent t test evaluating significance of gains on the *TCS* Memory test by chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	14	**597.786**
Posttest Scores	14	**727.786**
Difference	**Standard Error**	**t value**
130	24.86	5.23

Significant beyond the .001 level

TABLE 54. Dependent t test evaluating significance of gains on the *TCS* Memory test by male chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	9	**625.556**
Posttest Scores	9	**734.778**
Difference	**Standard Error**	**t value**
109.2	21.987	4.967
	Significant at the .001 level	

TABLE 55. Dependent t test evaluating significance of gains on the *TCS* Memory test by female chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	5	**547.8**
Posttest Scores	5	**715.2**
Difference	**Standard Error**	**t value**
167.4	57.8	2.896
	Significant at the .045 level	

From the evidence presented in tables 53-55, it appears that the systematic memory practice within the *USA Junior Chess Olympics Training Program* produces transfer to other areas as demonstrated by the statistical significance reviewed above. Perkins and Salomon (1988) argue that transfer should occur because 1) disciplinary boundaries are fuzzy, 2) important strategies (e.g. the use of metacognitive strategies) cut across disciplinary lines, and 3) at intermediate levels of generality, thinking processes transcend contextual bounds.

Edward de Bono (1983) suggested that certain attitudes, habits, and skills transfer from the learning task to the target task.

TABLE 56. *TCS* Verbal Reasoning test scores

ID #	PRETEST	POSTTEST	GAIN OR LOSS
1	715	715	0
3	331	493	162
4	664	715	51
5	547	580	33
7	512	614	102
8	614	715	101
9	635	664	29
10	715	715	0
12	493	493	0
13	563	614	51
14	512	614	102
15	529	547	18
16	529	547	18
18	596	664	68

TOTAL PRETEST:	7955
AVERAGE PRETEST:	68.2142857
STANDARD DEVIATION OF PRETEST:	96.87855326
VARIANCE OF PRETEST:	9385.454082
TOTAL POSTTEST:	8690
AVERAGE POSTTEST:	620.7142857
STANDARD DEVIATION OF POSTTEST:	77.7306968
VARIANCE OF POSTTEST:	6042.061224
TOTAL GAIN OR LOSS:	735
AVERAGE GAIN OR LOSS:	52.5
STANDARD DEVIATION OF GAIN OR LOSS:	47.10891635
VARIANCE OF GAIN OR LOSS:	2219.25

In the above table, Table 56, the results are not quite so impressive. As listed in the *TCS Technical Report,* the mean scale score on the Verbal Reasoning test for sixth graders across the nation is 578. The pretest mean score for the sixth grade students in this study scored an average of 568.214. Although the scale score norms are nearly 10 points higher for the national sample, there is no significant variance between the norms and the test group.

The posttest scale scores averaged 620.714 for an average gain of 52.5 points. Inspection of the scores in the above table shows that none of the students exhibited a loss; however, three students showed no gain. Two of those students missed only one problem on both the pre and the posttest. By using Table 6 in the *Norms Book,* I calculated pre and post percentile ranks to be 45% and 61%, respectively, for a gain of 16% (about half the increase noted on the Memory test). Remembering that no increase in percentile score is the norm, it is possible to conclude that the chess group's score does indicate an **above average** performance.

Because percentile scores are inappropriate for statistical analysis, I employed scale scores (as recommended in the *TCS Technical Report*) to perform the t test. The obtained t = 4.018, which is statistically significant at the .002 level.

While the results are not as statistically significant as the *TCS* Memory Test, transfer of training is very evident. These results correlate strongly with the transfer demonstrated in Dr. Stuart Margulies 1992 study, *The Effect of Chess on Reading Scores: District Nine Chess Program Second Year Report*. Dependent gains for the chess group in his study were significant beyond the .01 level.

TABLE 57. Dependent t test evaluating significance of gains on the *TCS* Verbal Reasoning test by chessplayers

VARIABLE	**NUMBER**	**MEAN**
Pretest Scores	14	568.214
Posttest Scores	14	620.714
Difference	**Standard Error**	**t value**
52.5	13.066	4.018

Significant at the .002 level

TABLE 58. Dependent t test evaluating significance of gains on the *TCS* Verbal Reasoning test by male chessplayers

VARIABLE	**NUMBER**	**MEAN**
Pretest Scores	9	565.778
Posttest Scores	9	624.889
Difference	**Standard Error**	**t value**
59.11	17.519	3.374

Significant at the .01 level

TABLE 59. Dependent t test evaluating significance of gains on the *TCS* Verbal Reasoning test by female chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	5	572.6
Posttest Scores	5	613.2
Difference	**Standard Error**	**t value**
40.6	19.844	2.046

Lacks significance at the .11 level

Table 60. Statistical Summary of t Tests for *TCS*

TABLES	MEMORY *p<*	VERBAL REASONING *p<*
MALES & FEMALES COMBINED:		
Dependent Chess Group	0.001	0.002
Population Mean Chess vs. National Norms	0.001	0.066
MALES:		
Dependent Chess Group	0.001	0.01
Population Mean Chess vs. National Norms	0.001	0.128
FEMALES:		
Dependent Chess Group	0.045	0.11
Population Mean Chess vs. National Norms	0.077	0.406

Discussion of the Findings for Study III

This study was an empirical investigation designed to determine whether there is a significant difference on Verbal Reasoning and Memory test scores between students who study chess and the national norms of students at their grade level.

1. $\boldsymbol{mM_a = mM_b}$ ***(<u>m</u> represents memory test)***

$\boldsymbol{mM_a}$ is the ***M***ean for the chess group on the memory test.

$\boldsymbol{mM_b}$ is the ***M***ean of the national norms on the memory test.

Based on the data collected and listed on pages 140-144:

$\boldsymbol{mM_a} = 727.786$

$\boldsymbol{mM_b} = 591$

it is possible to reject the first null hypothesis at the 99% confidence level.

2. $\boldsymbol{vrM_a = vrM_b}$ ***(<u>vr</u> represents verbal reasoning test)***

$\boldsymbol{vrM_a}$ is the ***M***ean for the chess group on the reasoning test.

$\boldsymbol{vrM_b}$ is the ***M***ean of the national norms on the reasoning test.

Based on the data collected and listed on pages 145-148:

$\boldsymbol{vrM_a} = 620.714$

$\boldsymbol{vrM_b} = 578$

It is possible to reject the second null hypothesis at the 93% confidence level.

1. *Will chess instruction and play enhance memory?* As in the Republic of Kishinev chess experiment, improvement in memory was noted.
2. *Will chess instruction and play enhance verbal reasoning?* As demonstrated in Margulies' research, chess in this study appeared to enhance both reading skills and verbal reasoning.
3. *Will students who are **required** to take chess lessons enjoy it?* Most of the students enjoyed the program; however, the less competitive pupils (primarily the females) found the matches and more advanced lessons less palatable. Individual gains appeared to be slightly lower for the less competitive types.

It is evident from the above tables and data that chess had a definite impact on developing both memory and verbal reasoning skills. ***The effect of***

the magnitude of the results is strong (***eta***^{2} is .715 for the Memory test gain compared to the Norm). Because the sample size of the treatment group was only 14 students, I would encourage replication of this study.

It was also evident that there were significant gains in the participants' chess skills. Seven of the boys involved in this study participated in the March 1988 Pennsylvania State Scholastic Championship. After having played chess for only five months, they finished second (only half a point behind Steve Shutt's nationally famous team from the Frederick-Douglass School in Philadelphia). One pupil even made the top fifty list for his age group.

Summary and Interpretation

The primary purpose of these studies was to determine what influence chess would have on students who were systematically exposed to it. Students in Studies II and III were encouraged to use the same thought processes on real life problems to promote transfer of problem solving skills.

Langen (1992) claims that “children who learn chess at an early age achieve more in the traditional maths and sciences. Chinese, European, and American research all find significant correlational values after just one year of systematic chess exposure.” Langen also states, “The most striking benefits are those associated with problem-solving and creativity.”

Langen goes on to say, “University symposia, like the *Chess and Mathematics* conference at Forli, Italy, in September 1992, now take the chess and math relation as established.” Chess was integrated into the French Canadian school systems beginning in 1984. The New Brunswick research showed that problem solving skills increased an average of 19.2% after the chess in math program was introduced.

Why does chess have this impact? Why did chessplayers score higher on the *Torrance Tests of Creative Thinking* as well as the *Watson-Glaser Critical*

Thinking Appraisal? Briefly, there appear to be at least seven significant factors: 1) Chess accommodates all modality strengths. 2) Chess provides a far greater quantity of problems for practice. 3) Chess offers immediate punishments and rewards for problem solving. 4) Chess creates a pattern or thinking system that, when used faithfully, breeds success. The chessplaying students had become accustomed to looking for more and different alternatives, which resulted in higher scores in fluency and originality. 5) Competition. Competition fosters interest, promotes mental alertness, challenges all students, and elicits the highest levels of achievement (Stephan, 1988). 6) A learning environment organized around games has a positive effect on students' attitudes toward learning. This affective dimension acts as a facilitator of cognitive achievement (Allen & Main, 1976). Instructional gaming is one of the most motivational tools in the good teacher's repertoire. Children love games. Chess motivates them to become willing problem solvers and spend hours quietly immersed in logical thinking. These same young people often cannot sit still for fifteen minutes in the traditional classroom. 7) Chess supplies a variety and *quality* of problems. As Langen (1992) states, "The problems that arise in the 70-90 positions of the average chess game are, moreover, new. Contexts are familiar, themes repeat, but game positions never do. This makes chess good grist for the problem-solving mill."

I concur wholeheartedly with Billings (1985), who wrote, "The most important skill a gifted student can learn is how to THINK more CREATIVELY and EFFECTIVELY." Based upon the results of the research reviewed in this book, I urge the inclusion of chess to augment the skills of both the gifted and the nongifted.

The *USA Junior Chess Olympics Training Program* used in each of my studies demonstrated effectiveness in bringing about the desired growth in the participating students. I would strongly recommend the adoption or adaptation of the *USA Junior Chess Olympics Training Program* within the school curriculum throughout the country.

In Study II both experimental groups achieved significant gains, but it should be pointed out that the chess group was tested in actual competition. Every game was real and different. The SAT group repeated the ***same*** practice test (on the computer) that they had already taken. There were no new or different problems to think about or solve.

The third study also demonstrated significant treatment effects on the dependent variables. These results suggest that transfer of the skills fostered through the chess curriculum did occur, and that the treatment was more effective among the more competitive students.

Since Binet's studies over one hundred years ago demonstrated that chessplayers had superior memory and imagination, it is reasonable to surmise that these characteristics are the result of continuous exposure to chess and not, as is usually assumed, prerequisites of the game. Certainly the Republic of Kishinev's chess experiment noted improvement in memory and imagination. Holding (1985) also concluded that chess could help develop memory. My studies appear to confirm this conjecture, in as much as the chess treatment groups significantly increased in both memory and imagination (creativity).

Pfau (1983) found that tests of verbal knowledge correlated highly with chess skill. The New York City School research showed that chess participation enhances reading performance. Margulies (1991) cited four possible reasons for the significant transfer from chess to reading: 1) the enhancement of general intelligence (as demonstrated in the Venezuela study); 2) increased self-esteem; 3) peer acculturation; 4) similarity of skills and cognition for both chess and reading. Additional arguments might include the ongoing verbal thought process that auditory learners employ when calculating chess moves or the fact that many chessplayers become motivated to read chess books to get better. By reading more, their reading skills improve. Undoubtedly a combination of these factors affects the growth of the students. In my third study, which included many poor readers, the students showed significant growth in verbal reasoning skills. After only one year of chess study in Zaire, the students participating in the chess course showed a marked development of their verbal and numerical aptitudes.

A wide variety of sources in the literature point to the logic of chess being an effective vehicle for teaching thinking skills, but none offered any statistical basis. The Bradford ESEA Title IV-C Project appears to have broken significant new ground in this area. The study found that the chess treatment demonstrated the greatest growth over all other activities four years in a row. Since critical thinking is crucial in all aspects of life, it is imperative to disseminate the effects of this study and to implement a chess curriculum in the schools.

Chapter V. Summary, Conclusions, and Recommendations

You will observe with concern how long a useful truth may be known and exist before it is generally received and practiced on. –Benjamin Franklin

Organization of Chapter V

I. Summarizes everything covered in the first three chapters.

II. Reviews findings for Study I.

III. Summarizes Study II.

IV. Examines Study III.

V. Discusses conclusions of this research.

VI. Makes recommendations for implementation of the findings.

Summary of First Three Chapters

There is a pressing need, in the opinion of many educators, leaders, and employers, to teach young people how to think. Relevant to the assumed need for teaching thinking processes, this book reviewed two research projects and one pilot study that I designed and directed. These studies propose that critical and creative thinking can be taught using chess as the vehicle. My 1987-88 research also asserts that chess can be utilized to develop memory.

The utility of the chess problem as a tool for studying complex human thinking has two main sources: 1) chess abounds with the type of problems that push human cognitive capacity to its limits and 2) the game of chess is well defined in the objects (chess pieces), and the primitive operations (the moves) are known (Chase & Simon, 1973).

In Search of Excellence, Peters and Waterman (1982) cite the classic chess studies to show that the manager who thoroughly comprehends his or her organization will be better able to process data efficiently and thereby make superior decisions. It is obvious from these references and numerous others that chess is an accepted tool for studying problem solving.

The literature reviewed in chapter two helped to provide the basis for the questions and hypotheses for these studies: chess can be used as a vehicle to investigate human thought. Reports and findings of empirical studies indicate that chess can be used to investigate problem solving. Schmidt (1982) states that chess needs to become part of the school curriculum. He asserts, “students will develop analytical, synthetic, and decision making skills which they can transfer to real life” (p. 3).

Horgan (1987) also argues that chess can develop thinking skills. Dr. Schiff's research (1991) concluded “fluency, flexibility, originality, and elaboration are cognitive behaviors which can be successfully taught to our gifted student population through the art of chess.”

There is universal consensus in the literature that the teaching of reflective thinking is needed in our schools, a point persistently argued by Dewey.

Furthermore, research has demonstrated that the ability to think critically can be taught, measured, and evaluated. Many researchers indicated that critical thinking could be taught in all subjects and grade levels. My 1979-83 (Ferguson, 1983) study hypothesizes that chess, computer programming, and a variety of other mentally challenging activities can be used as tools to teach critical thinking in our schools. In a document submitted to the U.S. Department of Education, Hall recommended that chess be taught in the schools. He indicated that chess is a mentally demanding activity, which teaches the importance of planning. He stated, “Proficiency in chess seems to be related to inherent logic, problem solving ability, temperament, versatility in thinking, and appreciation for the beauty of the game” (p. 8).

Not only do my research studies have the potential to give empirical support for Hall's recommendation concerning teaching chess in the elementary and secondary schools, they may also provide data for study in other areas. Krogius, in his book *Chess Psychology,* indicated that Lasker's classification of styles of thinking needs more investigation.

The major goal of these studies, broadly stated, was to investigate different types of student interest areas that were presumed to help young people develop their problem solving (critical/reflective/analytical thinking) skills. More narrowly, the problem under investigation in these studies was to determine the influence of chess instruction and play upon critical and creative thinking and memory improvement.

The secondary goal was to create a practical curriculum or training program that could easily be adapted by other schools for teaching thinking skills through the vehicle of chess. I hoped to use student interest areas to motivate participants to increase both their critical and creative thinking skills.

Study II, a short pilot project, attempted to expand the first study by including both gifted and nongifted students and by adding a metacognitive dimension to the study. The purpose was to find out whether students could acquire the basic problem solving methods required and to transfer those processes to “real life” problems.

My 1986 pilot study focused on requiring students to identify their thought processes when solving problems, to verbalize their thinking systems, to write their individual systems, and to experiment with their systems by solving a variety of problems, including “real life” problems.

The 1987-88 research study, which was conducted in a self-contained sixth grade classroom, was specifically designed to test whether chess instruction and competition could be used to increase reasoning and memory skills for average students at the sixth grade level.

Study III was developed to work exclusively with nongifted students to determine whether the transfer of thinking skills noted in the earlier studies with predominantly gifted children could be repeated with nongifted pupils.

As these projects grew and emerged, several products evolved: a student written chess newsletter, a weekly chess column in the local paper written by the students, a variety of chess books authored by the students, numerous tournaments, a chess league, chess seminars, chess camps, simultaneous exhibitions, student run clubs in the elementary schools, a resident chessmaster, the *USA Junior Chess Olympics*, and the American Chess School, a nonprofit corporation dedicated to educating the public about this research and implementing chess programs in the schools.

Study I

All subjects in the first study were gifted and were in grades seven, eight, or nine. A total of 94 students completed both the pretests and posttests. The largest segment of the sample was the group of 43 eighth graders. All students chose which activities or programs they wished to participate in. The two most popular programs were chess and computers.

Students were pre- and posttested using the *Critical Thinking Appraisal* and *Torrance's Tests of Creative Thinking*. Alternate forms of the tests were administered annually.

Students were exposed to their interest area once a week for two hours in the resource room. In addition, some students elected to spend extra time on their topic throughout the school year.

The data were statistically analyzed using the F test (to check for homogeneity of variance), the t test (to measure the quantity of gain for significance), and the chi square test (to compare the number of students demonstrating growth).

Study II

Students ranged in grade from second through twelfth. Students chose between two areas: chess and SAT preparation. The chess group was very diverse, while the participants in the SAT group were quite similar.

Chess students were exposed to their interest area once a week for two hours in the resource room for gifted students. Some students did elect to do independent study in addition to this time. Students in the SAT group studied one to two hours per week using the computer and some studied manuals on their own time.

Study III

Students in this study were all sixth graders in the same self-contained classroom. The mean IQ of the class was 104.6. All students were required to take basically the same chess course used in the first two studies. A total of 14 pupils completed both the pre and Posttests (*TCS* Memory test and Verbal Reasoning test).

Generally, students received chess lessons two or three times each week and played chess daily. Several students competed in rated chess tournaments outside of school.

Data were statistically analyzed using the dependent t test to compare students' growth in verbal reasoning and memory.

For clarity, the three studies have been separated in this summary. All of the studies had certain common denominators: lesson plans, objectives, instructional methods, materials, resources, evaluation procedures, etc.

Typical Lesson Plan for All Three Studies

<u>STEP 1</u>

REVIEW the last lesson. (*approximately 10-15 minutes*)

STEP 2

INTRODUCE new concept and teach lesson. (*about 30 minutes*)

STEP 3

QUIZZES—all students do the quiz while the concept is fresh in their minds. If class time does not permit, students may be required to do at least one example to check for comprehension of the concept, and the quiz may be used as a take-home-quiz or assignment. (*generally 10-15 minutes*)

STEP 4

PLAY supervised games for round robin. Touch move. (*1 hour*)

STEP 5

INDIVIDUAL REVIEW—While students are playing games, the instructor reviews the quizzes with students **individually** (or in pairs) and checks them on basic skills. As the pupil successfully completes each objective, the instructor dates and initials the student's skills checklist.

When a student has successfully completed all quizzes and objectives for the current level, he/she receives a certificate of achievement indicating what level of the *USA Junior Chess Olympics Training* has been completed. The levels lend motivation to the program.

Study I. The ESEA Title IV-C Project: Developing Critical and Creative Thinking

Critical Thinking

The ESEA Title IV-C federally funded research project was approved for three years (six semesters). It was extended for one school year at local expense for a combined total of four years; however, in actuality it was ***not*** a four-year study, it was ***four one-year studies***.

The Title IV-C project was an investigation of students identified as mentally gifted with an IQ of 130 or above. Students in the nonchess groups exceeded those in the chess group in Mean IQ by 2.3 points, which is not significantly different. All participants were students in public, private, or parochial schools within the Bradford Area School District in grades 7 through 9. The individuals sampled in this study could not be randomly assigned to groups because the students' individualized education plans prescribed activities based on interests. The independent variables included chess instruction and play, problem solving with computers, Olympics of the Mind, Future Problem Solving, creative writing, Dungeons & Dragons, independent study, and small group investigations.

The primary independent variables reviewed in this book are the chess treatment, the computer treatment, and all nonchess treatments combined. Some treatments had only one, two, or three students involved which makes statistical testing impractical; therefore, the treatments were combined and labeled 'nonchess' group/treatment. Each group met once a week for 32 weeks in the gifted resource room at Bradford Area High School to pursue its interest area under my leadership. Most groups spent a total of 60-64 hours pursuing their preferred activity.

The dependent variables were the differences in the means of the posttests from the pretests. Data were collected from the *Watson-Glaser Critical Thinking Appraisal* and the *Torrance Tests of Creative Thinking*. The chi square test and the t test were applied to determine the level of statistical significance.

It is important to note that ***all*** scores reported for the *Watson-Glaser Critical Thinking Appraisal* (*WCTA* or *CTA*) are equivalent raw scores. Watson and Glaser (1964, p. 8) used a procedure called equi-percentile equating to determine equivalent raw scores. These scores were all based on norms for high school students and beyond. Since this study was testing junior high level students and no norms exist for seventh and eighth graders, I was forced to use the high school norms and equivalent raw scores. In a few cases, pupils scored more correct on the posttest than on the pretest but showed a loss due to the equivalent raw score procedure.

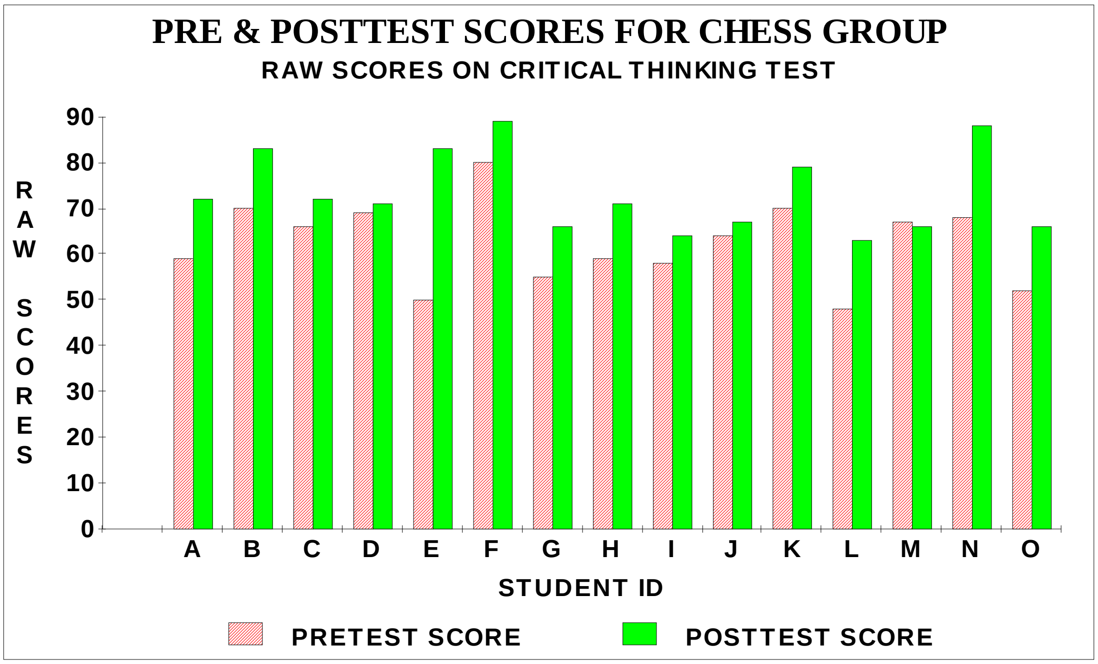


FIGURE I. A comparison of the pre and posttest scores for the chess group on the *Critical Thinking Appraisal*

Inspection of the pre and posttest results in the above figure shows that all but one chessplayer demonstrated gains in raw scores. The average annual increase in equivalent raw scores for the chess group was 10.53.

The average annual increase in percentile score for the chess group was 17.3%. Nationally, students who take this test at yearly intervals do not show a gain in percentile ranking. This comparison shows that the Bradford chess group significantly outperformed the average student in the country four years in a row.

A 50% score means the student is average in the country for that grade level on the *Watson-Glaser Critical Thinking Appraisal*. A score of 99% means the student is one of the best critical thinkers in that grade for the skills assessed by the *Watson-Glaser Critical Thinking Appraisal*. A student who scores in the 50th percentile in 1979 and who continues to perform in average fashion, will score in the 50th percentile in 1980. An increased percentile score indicates an above average performance.

Percentile scores are inappropriate for statistical analysis. In order to have an appropriate metric, the percentile scores were converted to ***equivalent*** raw scores and statistically analyzed using the t test.

Table A on the following page demonstrates that the chessplayers achieved a very significant gain ($p < .001$) from the pretest to the posttest in critical thinking skills as measured by the *Watson-Glaser Critical Thinking Appraisal*. The level of significance tells us that there is less than one possibility in a thousand that this result could have happened by chance.

TABLE A. Dependent t test evaluating significance of gains on the *Critical Thinking Appraisal* (*CTA*) by chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	15	62.80
Posttest Scores	15	73.33
Difference	**Standard Error**	**t value**
10.53	2.2	4.786

Significant beyond the .001 level

TABLE B. Independent t test evaluating significance of difference on

the *Watson-Glaser Critical Thinking Appraisal* between the chessplayers and nonchessplayers

VARIABLE	NUMBER	MEAN
Nonchess Group Gains	79	1.86
Chess Group Gains	15	10.53
Difference	**Standard Error**	**t value**
8.67	2.4	3.61

Significant at the .001 level

TABLE C. Statistical summary for *CTA*

TABLES	t Test *p<*	Chi Square X^2 *p<*
MALES & FEMALES COMBINED:		
Chess Group	**0.001**	
Chess vs. Nonchess	**0.001**	**0.008**
Chess vs. Computer	**0.003**	**0.008**
Chess vs. Nonparticipants	**0.025**	**0.002**
MALES:		
Chess Group	**0.003**	
Chess vs. Nonchess	0.072	0.056
Chess vs. Computer	**0.017**	**0.023**
FEMALES:		
Chess Group	**0.043**	
Chess vs. Nonchess	0.085	0.071
Chess vs. Computer	0.195	0.104
ALL 8TH GRADERS:		
Chess Group	**0.003**	
Chess vs. Nonchess	**0.006**	**0.009**
Chess vs. Computer	0.142	**0.05**

In a Fidelity Electronics' article entitled “The Minds of Tomorrow”

(1993), the company states, “In light of chessplaying's ability to shape future minds, schools all across the United States view chess as a powerful educational tool. Thousands of pre-teens and teens understand that chess coheres the mind to anticipate, make decisions, and react in a way no other game can.”

Dr. R.J. Topping (1988), the Coordinator of the Gifted/Talented Programs for the White Plains Public Schools, agrees with Fidelity and states:

> Chess is an integral part of the logic and creative problem-solving segment of our More Able Student curriculum. It cultivates critical thinking skills in our students, enhancing their personal growth and academic learning. We encourage other school systems to consider offering their students experiences in this dynamic content area (Chess in the Schools, 1988, p. 3).

Many teachers use chess as a vehicle to teach critical thinking skills. They stress to students that learning *how* to think is more important than learning the solution to a specific problem. Through chess, pupils learn how to invent creative solutions to problems. They learn how to analyze a situation by focusing on the important factors. Chess is effective because it is self-motivating. The game is intrinsically fascinating, and the goals of attack and defense, climaxing in checkmate, motivate young people to delve deep into their mental resources (Chess in the Schools, 1988, p. 2).

Creative Thinking

The next portion of the results and data analysis summary reviews the different aspects of creativity tested in this research: fluency, flexibility, and originality.

Verbal fluency is an individual's ability to generate a large number of ideas with words. Chessplayers often have a running dialogue within their minds reviewing the checklist for important strategic and tactical factors or mentally calculating, “If I go there, then he'll move . . .”

Flexibility represents a person's ability to produce a variety of types of ideas, to shift from one approach to another, or to use a variety of strategies.

Originality (Torrance, 1974) is skill at producing ideas that are different from the obvious, commonplace, banal, or established.

It is important to note that ***all*** scores reported for the *Torrance Tests of Creative Thinking* are standard T-scores. All raw scores were converted in accordance with the recommendations in the *Torrance Tests of Creative Thinking Norms-Technical Manual* (1974, pp. 48, 56). These scores were all based on creative thinking norms established for junior high school students.

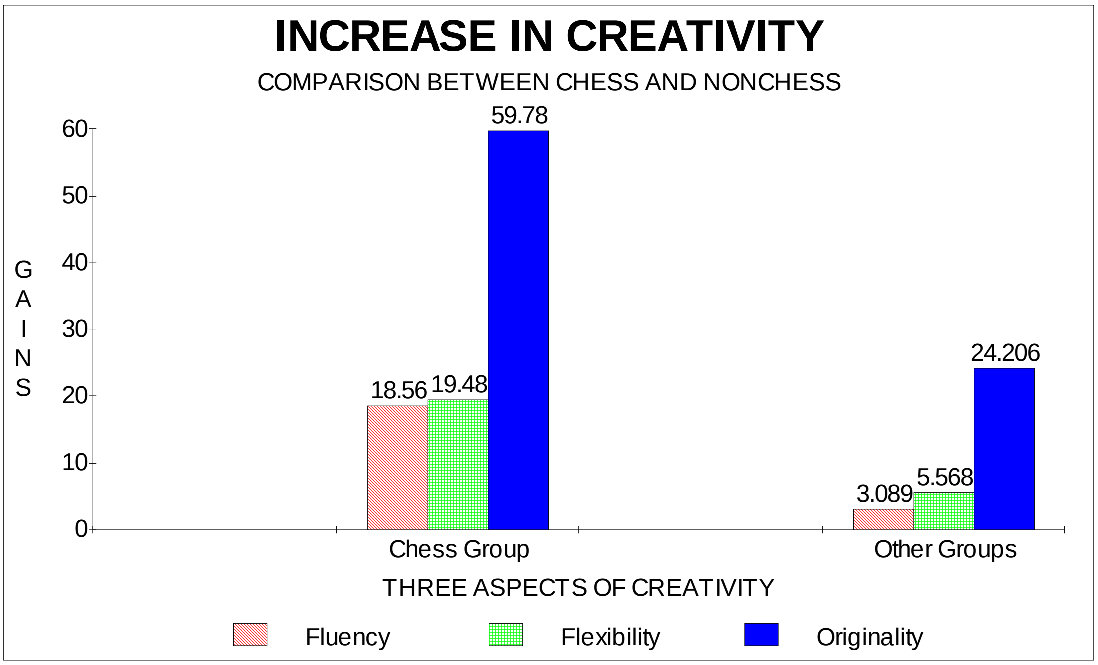


FIGURE II. A comparison of the chess group gains to the nonchess group gains

Dr. Redman compares the importance of creativity in chess to its importance in the arts and sciences. He writes:

> . . . this ability that is much ***encouraged*** and ***developed by chess***, what is this but the very essence of creativity? It is this very ability which produces the most lasting and significant contributions in both the world of art and the world of science. Any manifestations of this creative faculty should be encouraged by us as educators. (Redman, 1985, emphasis by Ferguson)

Creativity is a major aspect of the arts, sciences, and chess at the master level, but can chess influence creativity at the amateur level? The following summary table sheds some light on this question.

TABLE D. Statistical Summary of t Tests on Creativity

TABLES	FLUENCY	FLEXIBILITY	ORIGINALITY
	p<	*p<*	*p<*
MALES & FEMALES COMBINED:			
Dependent Chess	0.077	**0.024**	**0.01**
Population Mean Chess vs. Norms	**0.039**	**0.002**	**0.001**
Independent Chess vs. Nonchess	**0.049**	**0.05**	**0.018**
Independent Chess vs. Computer	**0.038**	0.08	**0.022**
MALES:			
Dependent Chess	0.142	**0.03**	**0.016**
Population Mean Chess vs. Norms	0.07	**0.008**	**0.003**
Independent Chess vs. Nonchess	**0.039**	**0.007**	**0.002**
Independent Chess vs. Computer	0.076	**0.018**	**0.007**
ALL 8TH GRADERS:			
Dependent Chess	0.32	0.088	**0.018**
Population Mean Chess vs. Norms	0.171	**0.037**	**0.019**
Independent Chess vs. Nonchess	0.305	0.061	**0.009**
Independent Chess vs. Computer	0.606	0.12	**0.027**
ALL 8TH GRADE MALES:			
Dependent Chess	0.32	0.088	**0.018**
Population Mean Chess vs. Norms	0.171	**0.037**	**0.019**
Independent Chess vs. Nonchess	0.383	**0.014**	**0.006**
Independent Chess vs. Computer	0.561	0.107	**0.02**

Discussion of the Findings for Study I

It is evident from the above tables and data that chess had a definite impact on developing both critical and creative thinking skills. Because the sample size of the treatment group was only 15 students, I would encourage replication of this study using a larger *N*.

It was also evident that there were significant gains in the participants' chess skills. Six of the pupils involved in this study participated in the annual Pennsylvania State Scholastic Championship beginning in 1980. Three of those six excelled. Two of the boys became candidate masters and one of the girls made the top 50 list for all women chessplayers in the United States.

Study II. The Tri-State Area School Study Council Project: Enhancing Critical Thinking Skills

This study focused on developing a personalized thinking system. Mentally gifted students at Bradford Area High School in grades 10-12 self-selected one of two options: SAT preparation or chess. Both treatments demonstrated short term gains that were statistically significant.

TABLE E. Review of the gains by both gifted and nongifted chess-players after pilot study

GIFTED STUDENTS	MEAN
Official Pre-Rating	1498
Performance Rating at States	1637
Short Term Unofficial Gain	139
Official Post-Rating one year later	1577
Long Term Official Gain	79
NONGIFTED STUDENTS	**MEAN**
Official Pre-Rating	1279
Performance Rating at States	1626
Short Term Unofficial Gain	347
Official Post-Rating one year later	1357
Long Term Official Gain	78
DIFFERENCE (GIFTED - NONGIFTED STUDENTS)	
Short Term Unofficial Gain	-208
Long Term Official Gain	1

The preceding table compares an equal number of nongifted students in grades nine and ten with gifted students in tenth through twelfth grade. All students were exposed to a systematic thinking development program for nearly two months prior to the Pennsylvania Scholastic Championship. The unofficial ratings were based upon all students' performances at the State Championship. The unofficial gain by the gifted students was 139, but the gain by the nongifted students was 347. While the short term unofficial gain by the nongifted students is over 27%, the gifted students short term gain was only a little more than 9%. If the short term performance gains of the nongifted are compared statistically to the gains of the gifted group using the independent t test, the difference is significant at the 0.009 level.

Official long term gains of both groups were calculated using the annual *USCF Rating Lists*. The official gains are nearly identical. The percentage of increase for the long term gain was only slightly larger (less than 1%) for the nongifted than for the gifted students.

TABLE F. Dependent t test evaluating significance of gains in the *official ratings* by <u>all</u> chessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Pretest Scores	264.94	1388.5
Posttest Scores	314.64	1467.0
Difference	**Standard Error**	**t value**
78.5	31.73	2.474

Significant at the .055 level

TABLE G. Dependent t test evaluating significance of gains in the *performance ratings* (short term gains) by all chessplayers

VARIABLE	**STANDARD DEVIATION**	**MEAN**
Pretest Scores	264.94	1388.5
Posttest Scores	236.13	1631.5
Difference	**Standard Error**	**t value**
243	46.507	5.225

Significant at the .004 level

TABLE H. Review of the gain by the gifted students in the SAT group

GIFTED STUDENTS	**MEAN**
Pretest Score on SAT	1085
Posttest Score on SAT	1114
Gain	29

Table H represents the gain made by the gifted students after two months of participating in the project. The scores are based on repeating (The same test was taken as both the pretest and posttest.) the same computerized practice tests using the CBS software *Mastering the SAT*. The short term gains appear meaningful. Using a related t test verified that the gain is significant at the .024 level. No records were obtained for scores on the actual SAT.

Discussion of the Findings for Study II

In Study II both experimental groups achieved significant gains, but it should be pointed out that the chess group was tested in actual competition. Every game was real and different. The SAT group repeated the ***same*** practice test (on the computer) that they had already taken. There were no new or different problems to think about or solve.

The unofficial (*performance*) gain by the gifted students was 139, while the unofficial gain by the nongifted students was 347. Considering the difference in grade levels, this seems to be a significant difference; however, some knowledge of the Swiss System is essential. Briefly, the Swiss System is a method of pairing players in which the lower rated ones are paired against the higher rated in the early rounds. Because the nongifted students were lower rated, they were paired up earlier than the gifted students with higher ratings. This accounts for part of the difference, but certainly competitive spirit and attentive use of the problem solving system were important factors.

It is inappropriate to compare the SAT group to the chess groups; however, it is worth noting the percentage of gain earned by each of the three groups during the short term study. The SAT group (comprised of gifted students in grades 10-12) increased 2.67% from the pretest score; the gifted students in the chess group gained 9.27%; the greatest gain (27.13%) was realized by the nongifted pupils in the chess group.

It would appear from this very short two month study that it is possible to enhance achievement by focusing on an individual student's modality strengths, creating an individualized thinking plan, analyzing and reflecting upon one's own problem solving processes, sharing his/her thinking system with peers, and modifying the system to integrate other modalities.

While caution should be used in interpreting this pilot study, it seems that because the chess group demonstrated both a larger quantity of gain and a greater significance in its short term gain than the SAT group, it is plausible that chess may enhance and expand these thinking concepts at a faster rate than SAT preparation.

Study III. The USA Junior Chess Olympics Research: Developing Memory and Verbal Reasoning

During the 1987-88 investigation, all students in a sixth grade self-contained classroom at M.J. Ryan School (*a rural school about 18 miles from Bradford, PA, with a student enrollment of 116 in grades K-6*) were required to participate in chess lessons and play games. None of the pupils had previously played chess. This experiment was more intensified than my other studies because students played chess daily over the course of the project. The project ran from September 21, 1987 to May 31, 1988.

The dependent variables were the gains on the *Test of Cognitive Skills* Memory subtest and the Verbal Reasoning subtest from the *California Achievement Tests* battery. The differences between the pretests and posttests were measured statistically using the t test of significance. Gains on the tests were compared to national norms as well as within the treatment group. The differences between males and females on the tests were also examined.

The mean IQ of the class participants was 104.6. All students were required to take basically the same chess course used in my first two studies. A total of 14 pupils (9 boys and 5 girls) completed both the pre and posttests (*TCS* Memory test and Verbal Reasoning test).

Generally, students received chess lessons two or three times each week and played chess daily. Several students competed in rated chess tournaments outside of school. Seven competed in the Pennsylvania State Scholastic Chess

Championship, and two went on to the National Elementary Chess Championship in Southfield, Michigan.

Results and Data Analysis

All scores reported for the *Test of Cognitive Skills* are listed as ***scale scores***. Scores have been converted from number correct scores to scale scores using conversion Table 3 in the *TCS Norms Book* for level 3. According to the *Norms Book*, "The scale score is the basic score for *TCS*. This score is especially appropriate for research studies and statistical analyses . . ." (1981, p. 7).

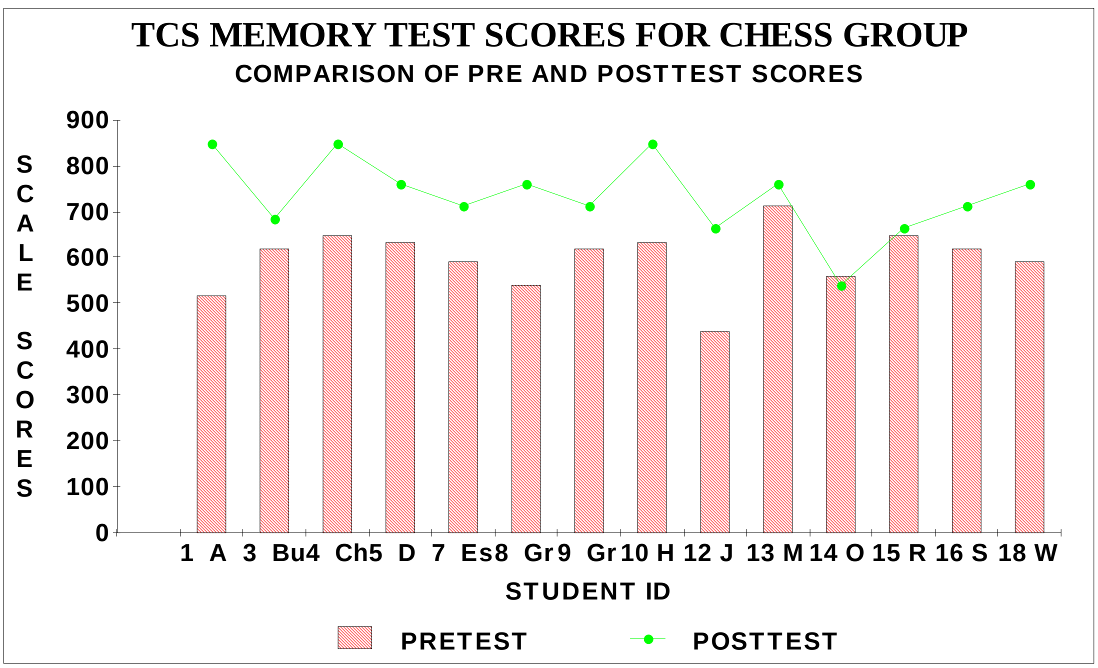


FIGURE III. Comparison of pretest and posttest scores on the *Test of Cognitive Skills* Memory test

As listed in the *TCS Technical Report* (1983), the mean scale score on the Memory test for sixth graders across the nation is 591. The pretest mean score for the sixth grade students in this study scored an average of 597.786. Using the F test to check homogeneity of variance, there is no significant difference noted between the norms and the test group.

The posttest scale scores averaged 727.786 for a mean gain of 130 points. Inspection of the scores in the above figure shows that all but one student demonstrated a gain. By using Table 6 (on pages 53 and 55) in the 1981 *Norms Book* for Level 3, I calculated the mean pre and post percentile ranks to be 59% and 91%, respectively, for an average gain of 32%. This increased percentile score indicates an ***above average*** performance.

An ***average*** student in the sixth grade scores at the 50th percentile on the subtests of the *Test of Cognitive Skills*. If the student continues to grow in proficiency at an average rate throughout the year, that student will again score at the 50th percentile in seventh grade. Considering that no percentile gain is the norm, the chess group's gain of 32 in percentile score appears significant.

Because percentile scores are considered inappropriate for statistical analysis, I used the scale scores to perform the t test. The t test measures the quantity of the gain to assess whether it is significant.

When comparing the treatment group to the sixth grade national norms, the obtained t equals 5.926, which is statistically significant beyond the .001 level. Even when I compared the sixth graders' posttest results to those of the seventh grade norms, the t test resulted in an obtained t=5.493, which is statistically significant beyond the .001 level. Something other than chance is demonstrated by this significant difference.

TABLE I. Dependent t test evaluating significance of gains on the *TCS* Memory test by chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	14	**597.786**
Posttest Scores	14	**727.786**
Difference	**Standard Error**	**t value**
130	24.86	5.23

Significant beyond the .001 level

As listed in the *TCS Technical Report*, the mean scale score on the Verbal Reasoning test for sixth graders across the nation is 578. The pretest mean score for the sixth grade students in this study scored an average of 568.214. Although the scale score norms are nearly 10 points higher for the national sample, there is no significant variance (as measured by the F test) between the norms and the test group.

By using Table 6 in the Level 3 *Norms Book*, I calculated pre and post percentile ranks to be 45% and 61%, respectively, for a gain of 16% (about half the increase noted on the Memory test). Remembering that no increase in percentile score is the norm, it is possible to conclude that the chess group's score does indicate an ***above average*** performance.

Because percentile scores are inappropriate for statistical analysis, I used the scale scores to perform the t test. The posttest scale scores averaged 620.714 for a mean gain of 52.5 points. The obtained t equals 4.018, which is statistically significant at the .002 level. Inspection of the scores in the table below shows that there are only two chances in a thousand that this result could have happened by coincidence.

TABLE J. Dependent t test evaluating significance of gains on the *TCS* Verbal Reasoning test by chessplayers

VARIABLE	NUMBER	MEAN
Pretest Scores	14	568.214
Posttest Scores	14	620.714
Difference	**Standard Error**	**t value**
52.5	13.066	4.018

Significant at the .002 level

Table K. Statistical summary of t tests for *TCS*

TABLES	MEMORY *p<*	VERBAL REASONING *p<*
MALES & FEMALES COMBINED:		
Dependent Chess Group	**0.001**	**0.002**
Population Mean Chess vs. National Norms	**0.001**	0.066
MALES:		
Dependent Chess Group	**0.001**	**0.01**
Population Mean Chess vs. National Norms	**0.001**	0.128
FEMALES:		
Dependent Chess Group	0.045	0.11
Population Mean Chess vs. National Norms	0.077	0.406

Discussion of the Findings for Study III

A ***significant*** difference is less than **.05** (often written $p < .05$). A ***very significant*** difference is one for which the probability of having occurred by sampling error is less than 1% (**.01**) and is frequently written $p < .01$ (Phillips, p. 85, 1973). In the statistical summary (Table K), the ***very significant*** levels have been **bolded**.

It is evident from the above tables and data that chess had a definite impact on developing both memory and verbal reasoning skills. The effect of the magnitude of the results is strong (eta^2 is .715 for the Memory test compared to the Norm). Because the sample size of the treatment group was only 14 students, I would encourage replication of this study using a greater sample size.

It was also evident that there were significant gains in the participants' chess skills. Seven of the boys involved in this study participated in the March 1988 Pennsylvania State Scholastic Championship. After having played chess for only five months, they finished second (only half a point behind Steve Shutt's nationally famous team from the Frederick-Douglass Elementary School in Philadelphia). One pupil even made the top fifty list for his age group.

General Conclusions

The results of these chess studies indicate that transfer of training occurs in critical and creative thinking, memory, and verbal reasoning. The transfer is not limited by one's intelligence quotient but may be impacted by competitive attitude. In addition to the competition factor, it appeared that males better assimilated the transfer process than females.

The information gathered in this book clearly points to the conclusion that chess can be used to provide scientific verification for the theories of Dewey concerning human thought. It is also obvious from these studies that the introduction of a chess course in the curriculum would be a positive step for schools that wish to improve their students' thinking and memory skills. As Dr. Redman writes, "Faced as we are with the continued decline of verbal and mathematical abilities among our high school students, chess offers itself to us as a ***remedy*** at that. Chess, we conclude, can serve as a positive educational influence upon our students, and can help them improve their verbal and mathematical skills." (Redman, 1985, emphasis Ferguson)

Students involved in independent study activities demonstrated the smallest gains in developing critical and creative thinking skills. Students in the computer group had a tendency towards improving their thinking skills, but there was no statistical significance in their gains. Only the chess treatment showed consistent, statistically significant gains.

Recommendations

As Dr. Stephen Mark Schiff (1991) so aptly stated, ". . . the study of chess is one of the most critically important additions to the curriculum that schools can offer to our pre-adolescent gifted and talented student population." I concur wholeheartedly with Dr. Schiff. Based on the results of Studies I, III, and others, I ***urge*** the inclusion of chess to augment the skills of both the gifted and the nongifted.

The *USA Junior Chess Olympics Training Program* used in each of the three studies undeniably demonstrated effectiveness in bringing about the desired changes in the participating students. I strongly recommend the adoption or adaptation of the *USA Junior Chess Olympics Training Program* within the school curriculum throughout the country.

Schools across the USA have already begun to implement the strategies used in these studies to enhance the thinking and memory skills of their students. New Jersey has passed a law making chess a part of the curriculum. Several schools in New York, Virginia, and elsewhere have made chess a required course to teach thinking skills.

I also recommend replication of these studies using multiple control groups. I urge a study with two groups using the *USA Junior Chess Olympics Training Program*, but one should use it without the metacognitive questions to determine the affect of that component. I would recommend that studies be made at all grade levels, so that the peak age for chess instruction could be ascertained.

I encourage additional research using the assessment tools selected in Study II: the Swassing-Barbe Checklist of Observable Modality Strength Characteristics, the Myers-Briggs Type Indicator, Dr. Gregore's Transaction Ability Inventory, and Renzulli's Learning Styles Inventory. Study II proposed several viable ideas that should be tested in depth for a longer time period to determine statistical significance.

Those desiring additional information about developing a chess curriculum, designing a research project, or implementing the *USA Junior Chess Olympics Training Program* may email the American Chess School at amchess@amchess.org or write to us at 140 School Street, Bradford, Pennsylvania 16701.

Certainly many of our Presidents (George Washington, Thomas Jefferson, Abraham Lincoln, and numerous others) have been chessplayers, and a host of Nobel Prize winners (Winston Churchill, Albert Einstein, Henry Kissinger, William Butler Yeats, Woodrow Wilson, etc.) played chess also. However, the fact that many famous people have chosen chess as a pastime has not been the point of this manuscript. Rather the essence, indeed the very truth, of this volume is perhaps best captured in the quote by world-renowned Dr. Tarrasch:

> Chess is a form of intellectual productiveness, therein lies its peculiar charm.

Intellectual productiveness is one of the greatest joys—if not the greatest one—of human existence. It is not everyone who can write a play, or build a bridge, or even make a good joke. But in chess everyone can, everyone must, be intellectually productive and so can share in this select delight. (Hartston, 1984)