Solving Academic Problems

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This paper focuses primarily on declining academic achievement (especially math and reading scores) along with self-esteem and thinking skills and the positive impact of chess.

Research shows that schools in the USA lag seriously behind those in the rest of the world in both math and reading. As a matter of fact, 63% of our high school graduates cannot read at a twelfth grade level. The United States now ranks 49th internationally in literacy, and only two countries (Cyprus and South Africa) finished behind the USA in basic math.

This report highlights the educational benefits of implementing chess in the schools. Many of the top-scoring schools in international studies appear to have a common denominator: chess as part of the curricula.

What problems confront our schools? Is there a simple cost-effective solution?

There are many problems facing our nation's educational system, and research points to an effective solution. Four of these major problem areas are:

1. Self-esteem - One-fifth of all 8th graders in the U.S. are considered to be at high risk of school failure. Approximately 30% of our youth drop out and fail to complete high school.
2. Math - In mathematics, U.S. twelfth graders perform above only two (Cyprus and South Africa) of the TIMSS countries. In advanced math, U.S. students performed better than only one country. Eighth graders did better but still finished in 28th place.
3. Reading - The USA ranks 49th internationally in literacy. Only 37% of high school graduates read at a twelfth grade level. 35% of college freshman take remedial courses.
4. Thinking skills - 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. "We are looking for kids who think," said Jon Reider, senior director of admissions at Stanford. (*Insight on the News*, 1998)

Many academicians around the world have completed years of research and arrived at the same conclusion: *chess enhances minds and inspires lives.* The quantity of research over the past three decades speaks for itself.

Relationship between Chess and Math

In a 1977-1978 study (Nurse, 1995) at the Chinese University in Hong Kong by Yee Wang Fung, chess players 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.

"**Étude 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)

In Texas, James Liptrap coordinated another research project demonstrating the impact of chess upon math. 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-chess players 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.

A 1998 study conducted by James Smith and Robert Cage, "**The Effects of Chess Instruction on the Mathematics Achievement of Southern, Rural, Black Secondary Students**," found significant gains in the chess group. The purpose of this study was to

determine the effects of 120 hours of chess instruction on the mathematics achievement of southern, rural, Black, secondary students. Instruments used were the mathematics section of the California Achievement Test (CAT) (Level 20), Witkins's Group Embedded Figures Test (GEFT), the Guilford-Zimmerman Spatial Visualization Test (SV), and Naglieri's Nonverbal Ability Test (NNAT). A 2 X 2 analysis of variance of the pre-tests found no significant differences in the scores of the treatment group (11 females, 9 males) and the control group (10 females, 10 males) by group or gender. However, a 2 X 2 ANCOVA of the post-test results found a statistically significant difference in the scores. The means of the group receiving ***chess*** instruction were significantly higher than the control group means on the CAT; GEFT; SV; and the NNAT. Statistically significant correlations were also found between all instruments on the pre-test scores.

In the 2006-07 research study by the Chess Academy Math Tutoring Program, John P. Buky reported that after just 60 hours of math tutoring, the 119 students participating demonstrated an average gain of 19% on a standardized mathematics test. Of the 119 students in the experimental group, 104 showed growth. Students in grades 1 through 8 participated in the study; however, the study appeared to help students in grades 1-6 the most. Only one seventh grade student demonstrated any gain in the post-test; this is probably due to the small number of seventh graders participating. The two-tailed P value is less than 0.0001, which means this difference is considered to be extremely statistically significant. The source for this study is http://www.thechessacademy.org/Math_Data.htm.

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. Faneuil Adams, Jr. and Bruce Pandolfini founded the New York City Schools Chess Program (NYCHESS) in 1986. 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 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 ("**The Effect of Chess on Reading Scores**") 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.

My fourth study (1998-1999), "**S.T.A.R. Pilot Project Findings**," took place at the fourth grade level at School Street Elementary in Bradford, PA. Three classrooms taught by male teachers were selected for the study. Two of the classes received chess enrichment, and the third served as the control group. Further, one class used the *Think Like a King* software. The school year time frame between the pre- and posttest was 0.79. The class using *Think Like a King* demonstrated an instructional reading level increase on the S.T.A.R. of 1.6 years beyond the control group. The second group receiving chess enrichment scored an increase of 1.5 years.

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 chess players scored 4.3 points higher in reading ($p<.01$). Dr. Frank's study included in the thinking section later in this paper 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 chess players have gone on to college. While pre and posttesting of these chess players has not occurred, common sense indicates that their chess experience had an extremely positive affect on them academically (Shutt, 1989).

Several educators have noted academic gains. 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.

Chess Development in Aberdeen's Primary Schools was a study funded by the Scottish Executive Education Department's Sponsored Research Programme in alliance with Aberdeen City Council. The study provides an in-depth account of the impact of the final year (2003 – 2004) of a three year New Opportunities Fund (NOF) programme of *Out of School Hours* activities which focused on the development of chess coaching for P4 pupils and chess after school clubs.

The programme was launched in 2001 and in its first year, chess development work was initiated in seven primary schools in the Northfield group - Muirfield, Westerton, Quarryhill, Holy Family, Bramble Brae, Middlefield and Smithfield schools. The project has since been extended.

This Scottish Research Project conducted in Aberdeen, Scotland found dramatic improvement in *attendance, social,* and *academic skills.*

Table 1a: Univariate Kurskal-Wallis tests (as an initial analysis of group differences)

	Improvement* (mean rank)				Baseline^ (mean rank)			
	(I) Mschool Chess coaching	(II) Mschool Problem solving PC games	(III) Dschool No specific input	*P-value*	(I) Mschool Chess coaching	(II) Mschool Problem solving PC games	(III) Dschool No specific input	*P-value*
a) Compreh-ension	32.6	28.4	21.4	*0.09*	22.7	28.4	31.4	*0.24*
b) Reading	32.5	26.5	23.5	*0.21*	25.4	28.8	28.3	*0.78*
c) Spelling	31.7	23.8	27.0	*0.31*	27.4	31.6	23.5	*0.31*
d) Word Test	25.1	35.1	22.2	*0.04*	27.6	28.2	26.6	*0.95*
e) Arithmetic	30.2	31.8	20.6	*0.07*	26.1	20.5	35.8	*0.01*
f) Social Adjustment	20.6	15.5	——	*0.04*	23.0	25.7	[28.1]	*0.45*
	N = 18	N = 18	N =18		N = 18	N = 18	N =18	

*Difference between the post- and pre-tests ^Pre-test

The results from the initial analysis in table 1a can be summarized as follows:

(a) Comprehension: There was evidence of 'marginal improvement' in group (I) over group (III), at $\alpha = 0.10$.
(b) Reading: Differences were not statistically significant, but the patterning of group 'improvement' in the study was similar to (a) and (c).
(c) Spelling: Differences were not statistically significant, but the patterning of group 'improvement' in the study was similar to (a) and (b).
(d) Word test: There was 'significant improvement' in group (II) only, at $\alpha = 0.05$, where there had been no statistically significant differences among the three groups at baseline, at the beginning of the study.
(e) Arithmetic: There was 'marginal improvement' both in groups (I) and (II) over group (III), at $\alpha = 0.10$, and that was from initial lower levels in both groups at the start of the study, when compared to group (III).
(f) Social Adjustment: There was 'significant improvement' in group (I) over group (II), at $\alpha = 0.05$, particularly given similar levels at baseline.

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, 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.

My third study during the 1987-88 school year dealt with both ***memory*** and reasoning skills. It is reviewed below in the "Relationship between Chess and Thinking" section.

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, which consisted of thirteen lessons plus playing time (Ruderman, "**Can Chess Improve Thinking, Social and Organizational Skill in Learning Disabled Students?"**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 Dr. Steven Fried and Dr. 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

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**." In one 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 away from the principal objective. The main point 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 widely recognized model that describes the process behind problem solving was developed by the renowned early twentieth century philosopher and educational theorist John Dewey. His reflective reasoning model separates problem solving into five steps. 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). This step is the crucial juncture in Dewey's theoretical framework of reflective thinking where the problem solver begins to make inferences. 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.

It is in this stage of analysis that 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)

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.

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 concrete level (stage 3) to the formal 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).

My first study, "**Developing Critical and Creative Thinking Through Chess,**" extended the support Dullea referenced. The ESEA Title IV-C federally funded research project was approved for three years (1979-82) and was extended for one school year (82-83) at local expense for a combined total of four years. The primary goal of the study was to provide challenging experiences that would stimulate the development of critical and creative thinking.

The Title IV-C project was an investigation of students identified as mentally gifted with an IQ of 130 or above. All participants were students in 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 primary independent variables reviewed in this summary are the chess treatment, the computer treatment, and all nonchess treatments combined. 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 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.

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 measurement, the percentile scores were converted to ***equivalent*** raw scores.

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. The data were also evaluated using a nonparametric, or distribution-free, test of significance. 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 nonchess players 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.

The chess group was compared to the nonchess group, the computer group, and the nonparticipants. The chi square test results ranged from marginally significant at .072 to very significant at .002. A listing of the t test and chi square test results may be found in Table 1.

TABLE 1. Statistical summary for the *Critical Thinking Appraisal*

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**

The second aspect tested in this study is that of creative thinking. Creativity is a major aspect of chess at the master level, but can chess influence creativity at the amateur level? Figure 2 and Summary Table 2 shed some light on this question. It would appear from the data collected and the statistical test results listed in the table on page 7 that there can be little doubt that chess does enhance creativity in gifted adolescents. Dr. Stephen Schiff's claim that creativity can be taught through the art of chess has been confirmed.

Robert J. Eaton, 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." (*U.S. News & World Report*, 115(25): A2, 1993).

While the entire chess group made superior gains over the other groups in all three areas, the aspect that demonstrated the most significant growth was ***originality***. It should be

noted that several researchers have found that gains in originality are usual 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 level when compared to the national norms is an important discovery.

Based on the data in Figure 2 and Table 2, it appears that chess is superior to many currently used programs for developing creative thinking and, therefore, could logically be included in a differentiated program for mentally gifted students.

TABLE 2. 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**

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 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.

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 *Weschler 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).

In 1986, I designed and directed the "**Tri-State Area School Pilot Study,**" which focused on developing a personalized thinking system. Mentally gifted students at Bradford H.S. 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 $p<.004$).

In this pilot study 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 the students had already taken. There were no new or different problems to think about or solve. Students in my second and third studies were encouraged to use the same thought processes on real life problems to promote the transfer of problem solving skills.

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 increased in all subjects.

Teachers noted improvement in ***memory***, better organizational skills, and for many increased fantasy and imagination (Education Ministry of the Moldavian Republic Kishinev, 1985).

During the 1987-88 "**Development of Reasoning and Memory Through Chess**," all students in a sixth grade self-contained classroom at M.J. Ryan School (*a rural school about 18 miles from Bradford, PA*) 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 program ran from September 21, 1987 to May 31, 1988.

The dependent variables were the gains on the *Test of Cognitive Skills* (*TCS*) Memory subtest and the Verbal Reasoning subtest from the *California Achievement Tests* battery. The differences from the pre 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 (the *USA Junior Chess Olympics Training Program*) 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. Many students competed in rated chess tournaments outside of school. Seven competed in the Pennsylvania Scholastic Chess Championship, and two went on to Nationals.

Table 3. Statistical summary of t tests for the *Test of Cognitive Skills*

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

It is evident from the above table 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). 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. Because the sample size of the treatment group was only 14 students, I would encourage replication of this study.

It was also obvious 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.

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).

Does chess make students smarter? More specifically, does a comprehensive chess education program improve a student's abstract reasoning and problem-solving skills? This study, conducted in July 2000 by James Celone at the Foote School in New Haven, Connecticut, sought to answer these questions by examining the performance of 19 elementary school students, ranging in age from 7 to 14, who were self-selected for a week-long program consisting of 20 hours of chess instruction. Students were tested before and after the program, using equivalent forms of the TONI-3 Test of Non-Verbal Intelligence, a valid and reliable instrument highly associated with abstract reasoning and problem solving, and using the Knight's Tour, a domain-specific instrument measuring overall chess problem-solving ability. The study found a significant increase between pre-test and post-test scores in both intelligence and domain-specific problem-solving ability. This extends and confirms earlier work done in 1975 by Christiaen in Belgium.

According to the review of literature, in a short term program the nonverbal tests had the most likelihood of showing significant improvement since they test for "academic potential." The verbal and quantitative portions were given but other research indicates that longer periods are needed to show improvements in this area. In essence, the nonverbal reveals improvement in metacognitive ability while the verbal and quantitative reflect the 'generalization' of metacognitive skills. Tests administered were Naglieri Nonverbal Abilities Test (measures non-verbal reasoning ability), CogAT Verbal, CogAT Quantitative, CogAT nonverbal (reflects ability to discover relationships and to demonstrate flexibility in thinking). The instruction period covered 10 weeks using *Think like a King* as part of the curriculum.

The results of Dr. Joseph Eberhard's research, "**The Relationship Between Classroom Chess Instruction And Verbal, Quantitative, And Nonverbal Reasoning Abilities of Economically Disadvantaged Students,"** are as follows:

	EXPERIMENTAL GROUP	CONTROL GROUP
All students NNAT	N=60, p<.002	N=93 p<.151
All students Verbal	N=60, p<.012	N=77 p<.555
All students Quant.	N=60, p<.510	N=77 p<.426
All students nonverbal	N=60, p<.000	N=88 p<.617
Econ. Disadv. NNAT	N=41, p<.045	N=55 p<.148
Econ. Disadv. Verbal	N=41 p<.187	N=47 p<.540
Econ. Disadv. Quant.	N=41 p<.785	N=47 p<.058
Econ. Disadv. nonverbal	N=41 p<.006	N=53 p<.152
Not Econ. Disadv. NNAT	N=19 p<.011	N=38 p<.591
Not Econ. Disadv. Verbal	N=19 p<.010	N=30 p<.180
Not Econ. Disadv. Quant.	N=19 p<.434	N=30 p<.249
Not Econ. Disadv. nonverb	N=19 p<.031	N=35 p<.443

Shiv Gaglani in his 2002 study, "**Problem-Solving Skill Enhancement through Chess**," found that the implementation of systematic chess training will enhance the problem-solving skills in elementary school students. Chess significantly increased ($t=2.081$, $d.f=23$, $p<0.025$) pattern recognition, divergent thinking, and logical reasoning skills. Chess also dramatically reduced ($t=3.574$, $d.f. =14$, $p<<0.01$) the time taken for test completion,

engendering quick and efficient problem solving. Twenty-five elementary students from 3rd grade to 5th grade with no previous knowledge of chess were recruited for the Harbor City Elementary Chess Club. In order to control some inevitable limitations such as age, maturity, and school curriculum, ten students made up the control group that did not undergo the variable, chess training. A pre-test was administered to the group before any chess training. The pre-test was based on the book Fundamentals of Mathematics, testing for pattern recognition, divergent thinking, and logical reasoning. Students learned chess skills through direct instruction, puzzles, and computer simulation. After 16 weeks of training, both the experimental and control group took a post-test.

Summary and Interpretation

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). Since Binet's studies one hundred years ago demonstrated that chess players had superior memory and imagination, it is not totally unthinkable that these characteristics might, in some way, be the result of continuous exposure to chess rather than being prerequisites of the game. Certainly the Republic of Moldova'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 chess players become motivated to read chess books to improve their game. 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.

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." He 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 chess playing 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 affect 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."

Why should we teach chess? Research has demonstrated that the ability to think critically can be taught, measured, and evaluated. Furthermore, there is universal consensus in the literature that the teaching of reflective thinking is needed in our schools, a point persistently argued by Dewey. Heidema at the 1983 *Conference of the Mind* stated, "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." (*Thinking in Elementary School Mathematics*, Mathematics and Science for the K-12 Curriculum, p. 104)

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 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).

Billings (1985) wrote: "The most important skill a gifted student can learn is how to THINK more CREATIVELY and EFFECTIVELY." I concur wholeheartedly with both Billings and 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 upon the studies examined in this brief paper, I ***urge*** the inclusion of chess to augment the skills of both the gifted and the nongifted.

Further support can be found from Schmidt (1982), who 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."

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. 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 results of this study and to implement a chess curriculum in the schools. 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.

Chess has been proven to enhance creativity, concentration, critical thinking skills, memory, academic achievement, problem solving, cultural enrichment, intellectual maturity, self-esteem, standardized test scores, and a host of other qualities that every administrator, school board director, parent, and teacher desires. The use of the best-known intellectual game to address the need to improve critical thinking, self-esteem, reading, and math is an innovative approach that has nationwide applicability. For more evidence and documentation of the educational benefits, please visit www.chess.isgenius.com or www.amchess.org.

Dr. Ferguson, a certified program specialist for the gifted, served as the Coordinator for Gifted Education in the Bradford Area School District in Pennsylvania. In addition, he authored and was project director for the grant, the 4th "R" Reasoning Program, which focused on the use of chess, as well as other intellectually stimulating activities to develop both critical and creative thinking skills. Dr. Ferguson has designed and directed four studies to identify the educational benefits of chess. He holds both elementary and secondary certification and taught in the K-12 sector for many years, in addition to the undergraduate and graduate levels.

Ferguson served as one of five members of the national U.S. Scholastic Council and is a past member of the USCF Executive Board and several committees. He is also the Executive Director for the American Chess School, which is best known for organizing the Castle Chess Camps.

This paper was originally prepared for the International Koltanowski Chess Conference held in Dallas, Texas in December 2001. It was updated recently to add newer research.