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CHESS IN EDUCATION RESEARCH SUMMARY

A REVIEW OF KEY
CHESS RESEARCH STUDIES

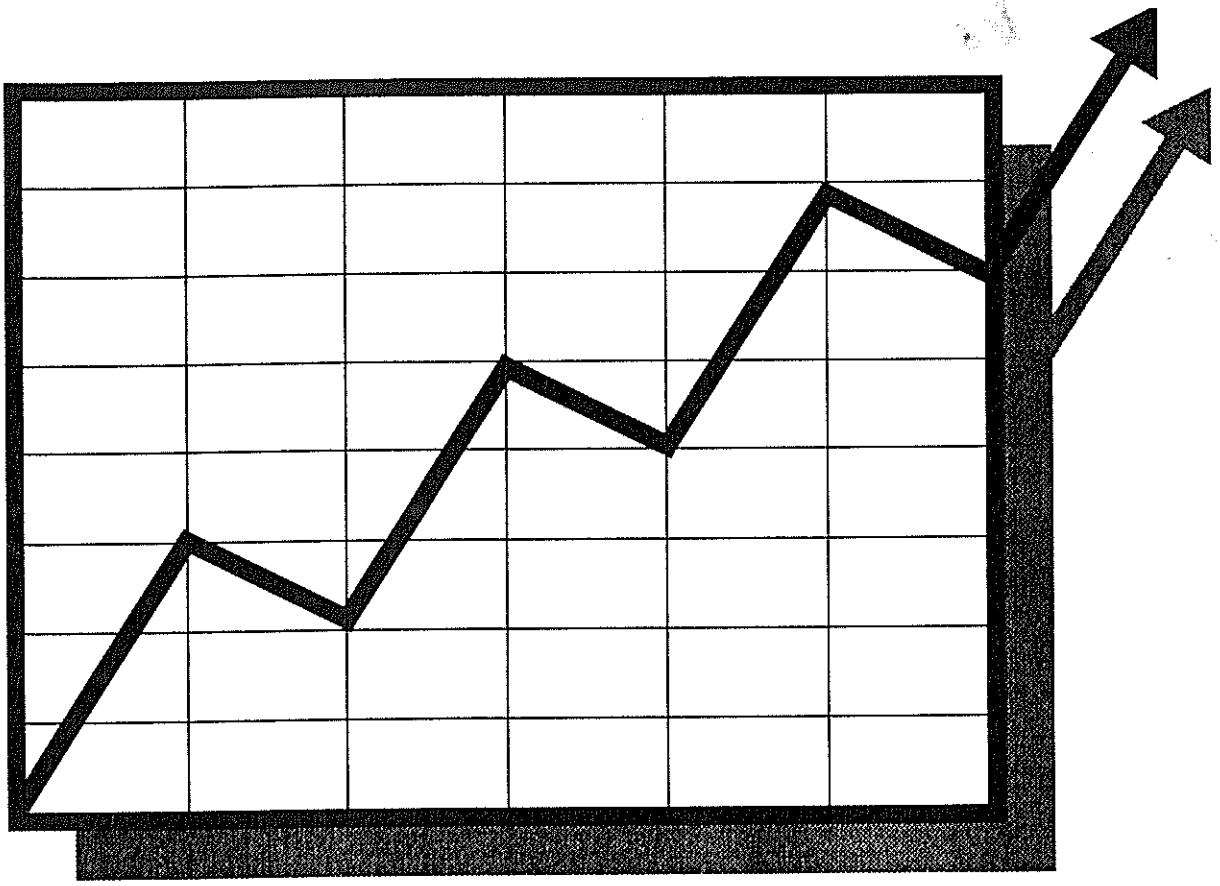
FOR THE

BMCC
CHESS IN EDUCATION
"A WISE MOVE"
CONFERENCE

PREPARED BY

Dr. Robert Ferguson, Jr.
Executive Director
American Chess School

Chess in Education Research Summary



This summary has drawn freely from several sources including Dr. Tim Redman's *Chess as Education: Character Assassination or Life of the Mind* and Robert Ferguson's doctoral dissertation. The following studies will be reviewed briefly in this paper.

- *Chess and Aptitudes* by Albert Frank
- *Chess and Cognitive Development* by Johan Christiaen
- *Developing Critical and Creative Thinking Through Chess* by Robert Ferguson
- *Tri-State Area School Pilot Study* by Robert Ferguson
- *The Development of Reasoning and Memory Through Chess* by R. Ferguson
- *The Effect of Chess on Reading Scores* by Stuart Margulies
- *Comparative Study of 5th Grade Math Curricula* by Louise Gaudreau
- *Playing Chess: A Study of Problem-Solving Skills* by Philip Rifner

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.

In 1925 Djakow, Petrowski, and Rudik studied grandmasters to determine the underlying factors of chess talent. The researchers determined that high achievement in chess is based on exceptional visual ***memory***, combination power, speed of calculation, power of concentration, and ***logical thinking*** (Djakow, Petrowski, and Rudik, 1927; bold italics by Ferguson).

Several have felt that chess not only demands these characteristics but also develops them. John Artise in **Chess and Education** states: "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." The following studies offer some hard evidence to support the claims of Artise and others.

The Zaire study, **Chess and Aptitudes**, 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 humanity's 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 *Rohrschach* 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 *Rohrschach* 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 vacations.

The study was intended to confirm two hypotheses about the affect 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. To play 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 experimental study up to that time.

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 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 the 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 aptitudes. The authors of the study

were puzzled by the latter result. They wondered how chessplaying 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 educational value in 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 conclude that the introduction of chess as a regular elective course in our high schools would be of positive benefit (correspondence from Harry Lyman, 1981).

The **Chess and Cognitive Development** research was directed by Johan Christiaen. The experiment was conducted during the 1974-76 school years at the Assenede 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 that included Piaget's tests for cognitive development and the *PMS* tests. The tests 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 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. The results at the end of sixth grade were significant at the .05 level. The subtest *DGB* relations and *PMS* total were significant at the .1 level.

Dr. Adriaan de Groot, noted psychologist and chess master, 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, clearcut 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 regard to the research, he also maintains: ". . . we have scientific support for what we have known all along--chess makes kids smarter!" (*Chess* Life, November, p. 16)

Ferguson's first study, **Developing Critical and Creative Thinking Through Chess,** extended the support Dullea referenced. Dr. Ferguson's ESEA Title IV-C federally funded research project was approved for three years (1979-82). It 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.

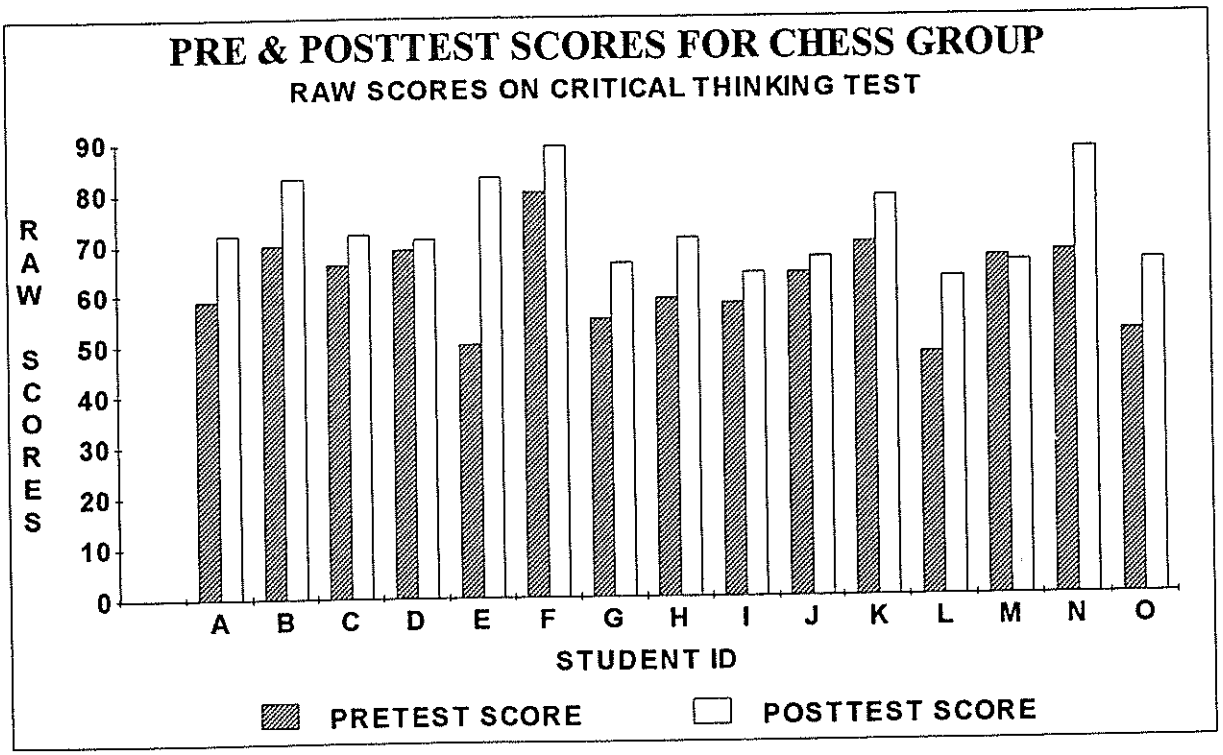


FIGURE 1. A comparison of the pre and posttest scores for the chess group on the *Critical Thinking Appraisal* Results and Data Analysis

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 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.

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 χ^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).

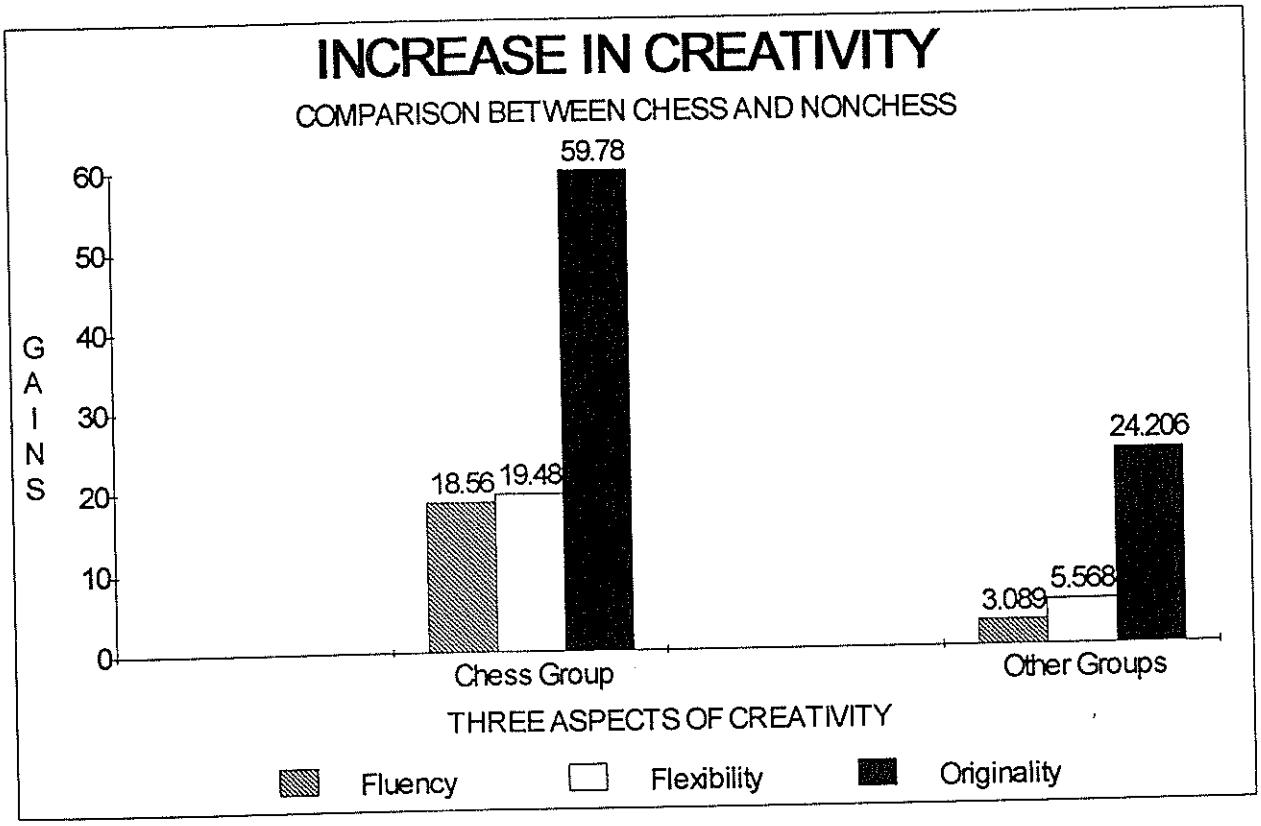


FIGURE 2. A comparison of the chess group gains to the nonchess group gains

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 $p<$	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**
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, Ferguson encourages 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, this researcher wrote several letters and scoured a variety of sources. The following paragraphs share these findings.

On August 25, 1984, the Fédération Internationale des Échècs (FIDÉ--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. (This author has tried several times to obtain a copy of this research, but apparently it has not yet been translated.) The Ministry for the Development of Intelligence trained 100,000 teachers to teach thinking skills. The initial project involved a sample of 4,266 second grade students.

The Venezuela experiment, **Learning to Think Project**, tested whether chess can be used to develop intelligence of children as measured by the *Wechsler Intelligence Scale for Children.*

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).

The **Tri-State Area School Pilot Study,** designed and directed by Robert Ferguson in 1986, 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 $p<.004$).

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 Ferguson's 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 Kichinov 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 Modavian Republic Kichinov, 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, 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 Ferguson's 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 Ferguson's 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, the author 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.

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 youths 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' (1991) **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 the chess program 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 of the 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' study conclusively proved that students who learned chess enjoyed a significant increase in their reading skills. *Inside Chess* (February 21, 1994, p. 3) states: "The Margulies Study is one of the strongest arguments to finally prove what hundreds of teachers knew all along--chess is a learning tool."

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).

The thinking behavior in reflective inquiry or reflective thought and the thinking behavior needed to evaluate a chess position are analogous. Dewey's five stages of inquiry are 1) awareness of perplexity, 2) definition of the problem, 3) entertainment of suggestions or hypotheses, 4) reasoning out the consequences of each hypothesis, 5) select hypothesis for the solution of the problem (Dewey, 1938). Dewey first identified these stages of reflective thought in his book How We Think (1910).

These same steps are used when a chessplayer analyzes a 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, bold emphasis by Ferguson).

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 exploded scholastic chess 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!

Playing Chess: A Study of Problem-Solving Skills in Students with Average and Above Average Intelligence by Philip Rifner was conducted during the 1991-1992 school term. The study 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.

Summary and Interpretation

We acknowledge that there is a need to improve critical and creative thinking skills in our nation. 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)

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 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. Chil-

dren 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."

Billings (1985) wrote: "The most important skill a gifted student can learn is how to THINK more CREATIVELY and EFFECTIVELY." This reviewer concurs 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, this researcher ***urges*** 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 Ferguson's studies demonstrated effectiveness in bringing about the desired growth in the participating students. This author would strongly recommend the adoption or adaptation of the *USA Junior Chess Olympics Training Program* within the school curriculum throughout the country.

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 Kichinov's chess experiment noted improvement in ***memory*** and ***imagination***. Holding (1985) also concluded that chess could help develop memory. Ferguson's 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 affect the growth of the students. In Ferguson's 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.

Why should we teach chess? What are the hard facts about chess and academic achievement? 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.

For Those Who Haven't Studied Statistics

"Tradition holds that the level of significance must be expressed as *the probability that a true null hypothesis is being rejected.* That means that the ***lower*** the significance level, the ***higher*** is our confidence that the effect we have observed is real." (Phillips, Statistical Thinking: A Structural Approach, p. 85, 1973)

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 $p<.01$. In each of the statistical summaries (Tables 1, 2, 3), the ***significant*** levels have been **bolded**.

For Additional Information

For additional information about the studies reviewed in this summary, please contact the United States Chess Federation by calling 914-562-8350 or by writing to:

U.S. Chess
186 Route 9W
New Windsor, NY 12550
USCF web page address is **http://www.uschess.org**

For additional information about the *Challenging Mathematics Program*, please contact the publisher in Canada by calling 800-561-2371 or by writing to:

Mr. Michel Solis
Mondia Éditeurs Inc.
Boulévard Industriel
Laval, Québec H7S 1P6

For additional information about any aspect of the *USA Junior Chess Olympics Training Program* (curriculum, teacher manuals, teacher training workshops, student workbooks, etc.), please contact the *Junior Chess Olympics* by calling 814-368-4974 or by writing to:

USA Junior Chess Olympics
140 School Street
Bradford, PA 16701
E-mail: *rcf1+@pitt.edu*
Web pages are at **http://www.penn.com/~mrpeter**
and **http://behavnet.com/chescamp/chescamp.html**