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

The 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. Students in the nonchess groups exceeded those in the chess group in Mean IQ by 2.3 points, which is not significantly different. All participants were students in the Bradford Area School District in grades 7 through 9. 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.

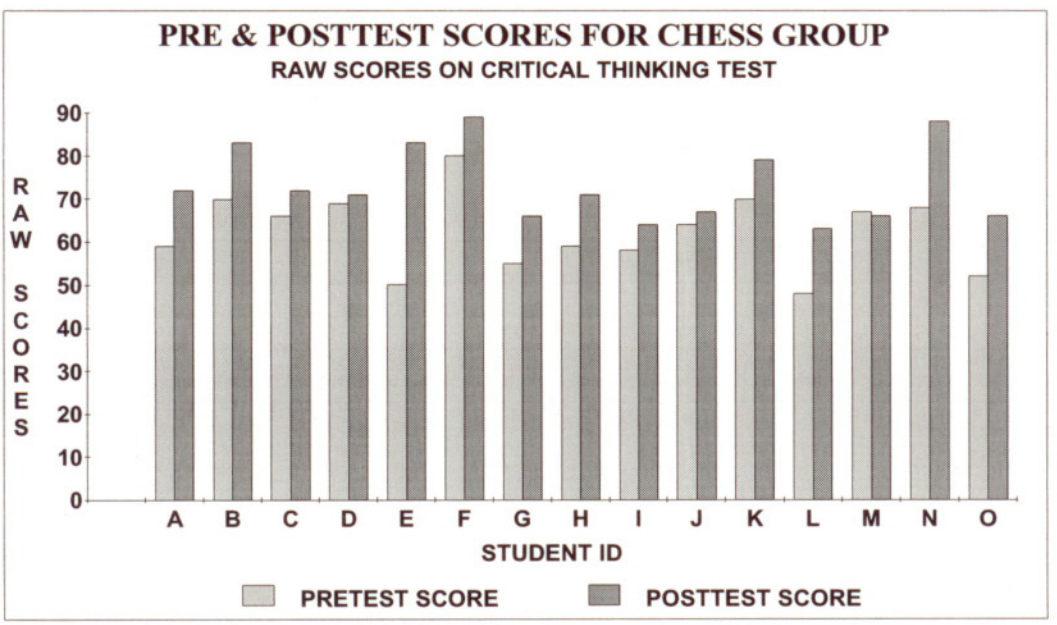

FIGURE 1. A comparison of the pre and posttest scores for the chess group on the *Critical Thinking Appraisal*

Results and Data Analysis

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

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

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

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

Percentile scores are inappropriate for statistical analysis. In order to have an appropriate metric, the percentile scores were converted to ***equivalent*** raw scores.

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

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

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

Significant beyond the .001 level

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

Just as the dependent t test illustrated above is extremely significant, so too is the independent t test illustrated in Table 2, which indicates that the chess group's performance is notably superior to that of the nonchess group's. The results, which are statistically significant at the .001 level, are shown in Table 2.

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

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

Significant at the .001 level

The data were also evaluated using a nonparametric, or distribution-free, test of significance. For Study I, the chi square test of statistical significance was used to evaluate the gains/losses on the *Watson-Glaser Critical Thinking Appraisal*. The chi square test evaluates the significance of the number of chessplayers demonstrating gains on the *CTA* compared to the number of non-chessplayers 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 complete listing of the chi square test results may be found in Table 3 on the next page.

Particular attention should be given to the results comparing the gains of the eighth graders on the *CTA*. These are perhaps the most significant of all the critical thinking results because eighth graders comprised 46% of the total number of students participating in the project. Out of a total of ninety-four pupils who completed both the pre and posttests, forty-three were eighth graders. Because this was the largest grade sample, it becomes more statistically important and increases our level of confidence in the results.

TABLE 3. Statistical summary for *CTA*

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

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

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

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

Many teachers use chess as a vehicle to teach critical thinking skills. They stress to students that learning *how* to think is more important than learning the solution to a specific problem. Through chess, pupils learn how to invent creative solutions to problems. They learn how to analyze a situation by focusing on the important factors. Chess is effective because it is self-motivating. The game is intrinsically fascinating, and the goals of attack and defense, climaxing

in checkmate, motivate young people to delve deep into their mental resources (Chess in the Schools, 1988, p. 2).

The next portion of the results and data analysis summary reviews the different aspects of creativity tested in this research: fluency, flexibility, and originality.

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

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

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

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

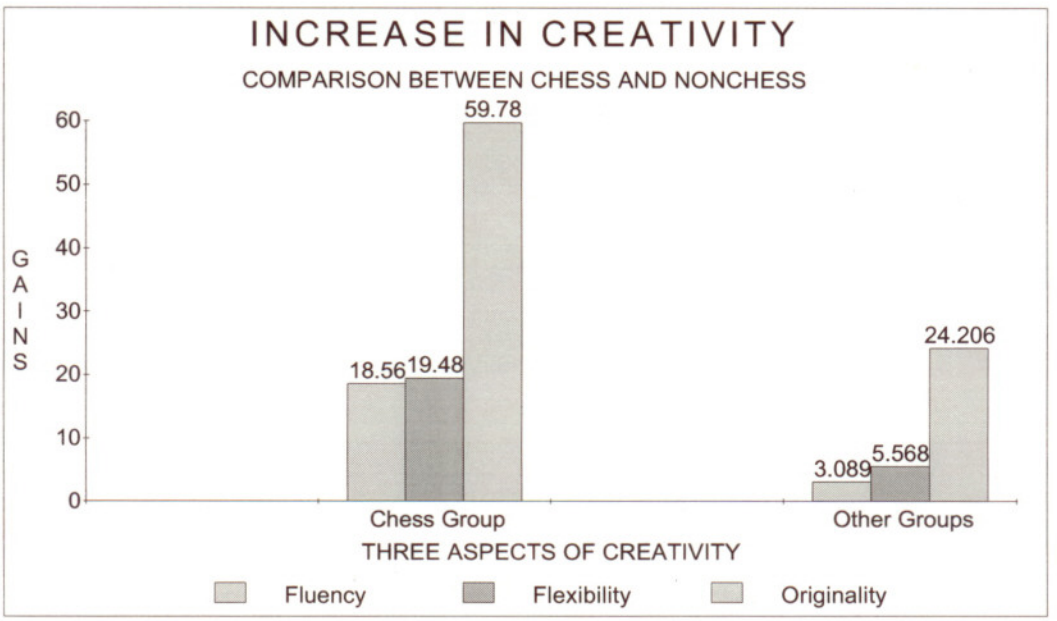

FIGURE 2. A comparison of the chess group gains to the nonchess group gains

Creativity is a major aspect of chess at the master level, but can chess influence creativity at the amateur level? Summary Table 4 sheds some light on this question. It would appear from the data collected and the statistical test results listed in the table below 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.

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.

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 4. 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**

Conclusions

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, the author would encourage replication of this study using a larger *N*.

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

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

The *USA Junior Chess Olympics Training Program* used in each of Ferguson's studies undeniably demonstrated effectiveness in bringing about the desired changes 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.

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)

Some researchers hold that a probability of **.1** (10%) is significant; however, in this study and Ferguson's other research, a ***significant*** difference is equal to or 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 the statistical summary (Table 4), the ***significant*** and ***very significant*** levels have been **bolded**.

For Additional Information

The preceding material is a brief synopsis of the information found in a paper (200+ pages) by Robert Ferguson entitled *Teaching the Fourth "R" (Reflective Reasoning) Through Chess.* If you would like a more comprehensive review of this research and his other studies, send a check for ***$39.95*** payable to the American Chess School at the address below. ***All profits from the sale of this publication are used to support chess in the schools.***

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Study II. Tri-State Area School Pilot Project Findings

Overview

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

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

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

The above table compares an equal number of nongifted students in grades nine and ten with gifted students in tenth through twelfth grade. All students were exposed to a systematic thinking development program for nearly two months prior to the

Pennsylvania State Scholastic Championship. The unofficial performance ratings were collected based upon all students performances at States. The unofficial gain by the gifted students was 139, but the unofficial gain by the nongifted students was 347. While the short term unofficial gain by the nongifted students is over 27%, the gifted students short term gain was only a little more than 9%. When the short

term performance gains of the nongifted group are compared statistically to the gains of the gifted group using the independent t test, the difference is significant at the 0.009 level.

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

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

all chessplayers

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

Significant at the .055 level

TABLE C. Dependent t test evaluating significance of gains in the performance ratings (short term gains) by all chessplayers

VARIABLE	STANDARD DEVIATION	MEAN
Pretest Scores	264.94	1388.5
Posttest Scores	236.13	1631.5
Difference	**Standard Error**	**t value**
243	46.507	5.225

Significant at the .004 level

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

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

Table D represents the gain made by the gifted students after two months of participating in the project. The scores are based on the computerized practice tests using the CBS software Mastering the SAT. The short term gains appear meaning. Using a related t test verified that the gain is significant at the .024 level. No records were obtained for scores on tine actual SAT.

Discussion of the Findings for Study II

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

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

It is inappropriate to compare the SAT group to the chess groups; however, it is

worth noting the percentage of gain earned by each of the three groups during the short term study. The SAT group (comprised of gifted students in grades 1012) increased 2.67% from the pretest score; the gifted students in the chess group gained 9.27%; the greatest gain (27.13%) was realized by the nongifted pupils in the chess group.

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

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

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Study III. The USA Junior Chess Olympics Research: Developing Memory and Verbal Reasoning

During the 1987-88 investigation, all students in a sixth grade self-contained classroom at M.J. Ryan School (*a rural school about 18 miles from Bradford, PA, with a student enrollment of 116 in grades K-6*) were required to participate in chess lessons and play games. None of the pupils had previously played chess. This experiment was more intensified than Ferguson's other studies because students played chess daily over the course of the project. The project ran from September 21, 1987 to May 31, 1988.

The dependent variables were the gains on the *Test of Cognitive Skills* (*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 PA Scholastic Chess Championship, and two went on to Nationals.

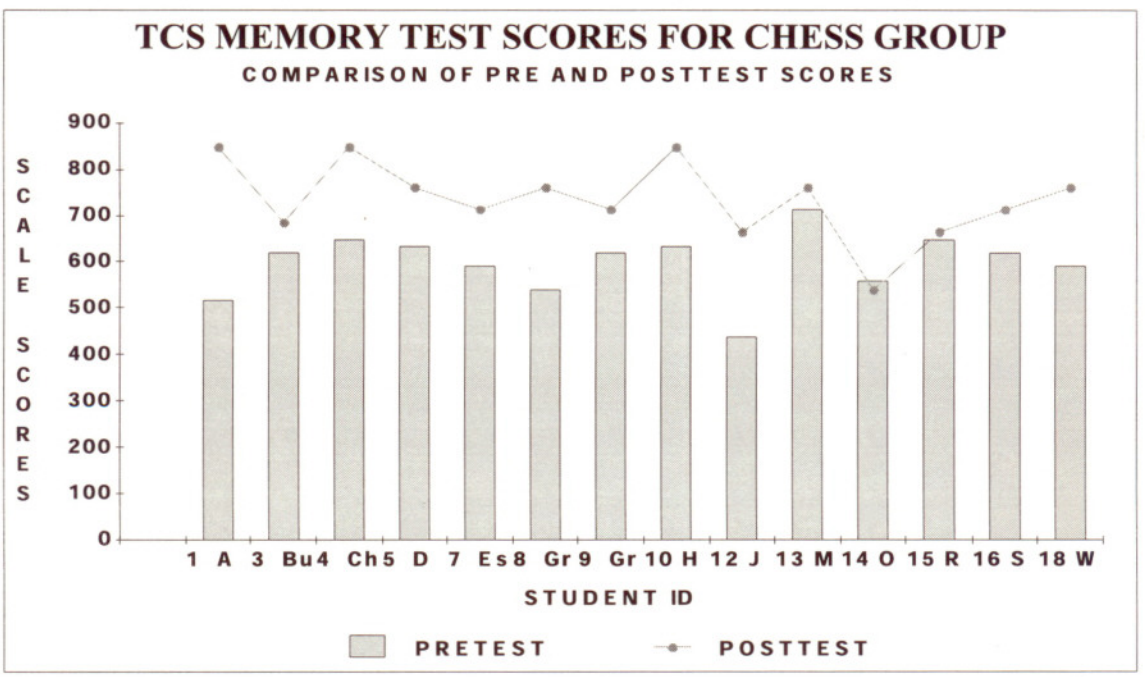

FIGURE 1. Comparison of pretest and posttest scores on the *TCS* Memory test

Results and Data Analysis

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

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

The posttest scale scores averaged 727.786 for a mean gain of 130 points. Inspection of the scores in Figure 1 on the first page shows that all but one student demonstrated a gain. By using Table 6 in the Norms Book, the project director calculated the mean pre and post percentile ranks to be 59% and 91%, respectively, for a gain of 32%. This increased percentile score indicates an ***above average*** performance.

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

Because percentile scores are considered inappropriate for statistical analysis, the director used the scale scores to perform the t test. The t test measures the quantity of the gain to assess whether it is significant.

When comparing the treatment group to the sixth grade national norms, the obtained t equals 5.926, which is statistically significant beyond the .001 level. Even when the researcher compared the sixth graders' posttest results to those of the seventh grade norms, the t test resulted in an obtained t=5.493, which is statistically significant beyond the .001 level. Thus the chances are less than one in a thousand that these gains were due to chance.

TABLE A. Dependent t test evaluating significance of gains on the *TCS* Memory test by chess players

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

Significant beyond the .001 level

As listed in the *TCS* Technical Report, the mean scale score on the Verbal Reasoning test for sixth graders across the nation is 578. The pretest mean score for the sixth grade students in this study scored an average of 568.214. Although the scale score norms are nearly 10 points higher for the national sample, there is no significant variance between the norms and the test group.

By using Table 6 in the Norms Book, the project director calculated pre and post percentile ranks to be 45% and 61%, respectively, for a gain of 16% (about half the increase noted on the Memory test). Remembering that no increase in percentile score is the norm, it is possible to conclude that the chess group's score does indicate an ***above average*** performance.

Because percentile scores are inappropriate for statistical analysis, the director used the scale scores to perform the t test. The posttest scale scores averaged 620.714 for a mean gain of 52.5 points. The obtained t equals 4.018, which is statistically significant at the .002 level. Review of the scores in the table below shows that there are only two chances in a thousand that this result could have happened by coincidence.

TABLE B. Dependent t test evaluating significance of gains on the *TCS* Verbal Reasoning test by chess players

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

Significant at the .002 level

Table C. Statistical summary of t tests for *TCS*

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

Conclusions

It is evident from the above tables and data that chess had a definite impact on developing both memory and verbal reasoning skills. The effect of the magnitude of the results is strong (***eta²*** is .715 for the Memory test gain compared to the Norm). 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 project director concurs wholeheartedly with Dr. Stephen M. Schiff (1991), who wrote: ". . . the study of chess is one of the most critically important additions to the curriculum that schools can offer to our pre-adolescent gifted and talented student population." Based on the results of Study III and others, 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 undeniably demonstrated effectiveness in bringing about the desired changes 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.

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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 the statistical summary (Table C), the ***very significant*** levels have been **bolded**.

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