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Effect of Chess and Study Skills Instruction on High School Achievement

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January 24, 2006

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Thanks to all the students, faculty, and staff at Apache Trail High School and to the principal, Randall Cook, for his assistance and participation.

Abstract

Effect of instruction, study skills and chess, no study skills, and prior chess, on three achievement and two critical thinking measures were examined in 78 high school students. Reading, Spelling, and Arithmetic from the WRAT3 were achievement measures. GALT and Watson Glaser Critical Thinking Appraisal scores were critical thinking measures. Gain score analyses revealed significant ($p = .01$) reading and significant ($p = .004$) arithmetic gains in the study skills and chess group. A significant ($p = .012$) solution to the canonical correlation analysis revealed that arithmetic and reading achievement related to final class grade, type of instruction received, and critical thinking. Results suggest empirical support for instruction in study skills and chess to increase aspects of academic achievement.

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With the national push for "No Child Left Behind Academically", and the educational push to increase academic achievement, the pressure builds for students to succeed academically. Schools, teachers, and administrators also are pressured to find curricular programs that work. Work in the sense that these programs successfully maximize student achievement and prepare students to graduate from high school and to be successful in either the work force or in college. If nationally, we are demanding greater achievement and excellence from our students, we must provide comparable training in teaching them how to be successful. Teaching study skills, organizational, and critical thinking skills to students who have never been taught how to be successful in school should support their academic achievement.

Numerous research studies exist that support the importance of teaching study skills and critical thinking skills such as chess to students. For instance, Margulies (1998) found that reading achievement improved significantly in a two year study of elementary chess players compared to no chess instruction. Over a four year period, Ferguson (1983, 1986) studied gifted students in grades 7 to 9 and compared special activity groups in chess, problem solving with computers, creative writing, independent study, and others and found that the chess group had significantly higher performance on measures of critical thinking and creativity than the comparison groups. Liptrap (1998) studied elementary students who were equivalent in reading levels in third grade and by fifth grade those who had participated in chess scored significantly higher than non-chess players on measures of reading and math. In a smaller study of sixth graders, Ferguson (2001) found significant gain scores in memory and verbal reasoning among those who received chess instruction.

Prior work (McClelland, 1979; Bandura, 1997) in the importance of study skills suggests that student use of study skills strategies increases motivation as well as achievement. Robinson (1961) and Mayer (1984) taught students to generate questions from text and found that this approach increased text comprehension. In a meta-analysis study, Rosenshine, Meister, and Chapman (1996) found that teaching students to ask questions increased their comprehension. However, no studies exist to support teaching chess and study skills to a high school population to determine their effect on academic achievement measures. Because of the lack of research studies that focus on the high school student, we conducted an initial research project to determine if study skills and chess instruction is effective in supporting broader achievement measures in a population of students in grades 9 to 12. Our study skills curriculum had two main components: an organizational and study skills component, and two, a critical thinking skills component which incorporated chess instruction.

Thus, the main purpose of this study was to compare type of instruction at three levels on three measures of academic achievement and two measures of logical thinking in high school students. The three levels of instruction were: study skills and chess, no study skills and chess, and prior chess. Reading, spelling, and arithmetic were the three measures of academic achievement. We conservatively proposed a nondirectional hypothesis that significant differences will exist among the three levels of instruction on achievement and logical thinking measures.

Method

Participants

The high school is a small, Arizona charter school with grades 9 to 12 with 206 students located in the eastern Phoenix valley. At the time of testing, 85% of its students were White and

14% were Mexican American. In addition, 55% were girls. The high school has a transient population and loses 40% of students from the beginning to the end of the academic school year that is subsequently replaced by new students. Based on school administrative reports, up to 30% of the students come from dysfunctional families (known family member problems due to drugs, alcohol, and/or abuse). Based on the previous year's group testing information as measured by the SAT9, each grade performs an average of two grade levels below the national norms.

Of the 206 students, 38 were eliminated from being randomly assigned due to participation in Block 3 where sections of the chess curriculum were field tested. Of the 178 remaining students, 28 were randomly assigned to the study skills and chess class, n=23 remained for the posttest. The no study skills and chess group had an initial n=25 and for the posttest an n=20. For those who had a beginning exposure to chess, the prior chess group, they were analyzed as a separate third group, for the pretest n=23 and for the posttest an n=20. Attrition was consistent among the groups. Two of the five students who dropped from the study skills and chess class were in a car accident and planned to return while the remaining students from all three groups dropped high school.

Also, we obtained the following demographic information: age, sex, grade level, final class grade. Several additional variables which we hoped to obtain for each student were not available due to the school registrar’s computer crashing: number of blocks completed at the high school, prior GPA (before attending the high school), current GPA (not including Block 4 classes), class rank, April 2003 SAT9 test scores, and number of days absent.

Procedures

The High School's instructional program was organized into four, 9-week blocks with three main class sessions per day (8 a.m. - 9:40 a.m., 9:40 a.m.-11:20 a.m., and 11:40 a.m.-1:20

p.m.). The high school did not offer separate classes for each grade, rather for any particular class, all grade levels were present. Each class period lasted 100 minutes. Students attended Monday through Thursday and made up absences on Fridays. Approximately 60 hours of instructional time were available for each period of the 9-week block. Block 4 began March 31 and ended June 3 with holidays on April 18 and May 23-26. Block 4 is when we began this study.

With approximately nine weeks, Monday through Thursday, a total possible instructional time of 60 hours was decreased by seven hours by the testing; an additional three hours were used by shortened class periods for other school activities. Thus, the total instructional time was 50 hours, not subtracting time taken for attendance and record keeping.

The study skills and chess class received study skills instruction on Monday and Tuesday and chess instruction on Wednesday and Thursday. Due to the limited time available to teach each, the study skills instruction focused on the following areas: organizational skills, how to read a chapter, how to spell and understand words better, how to take notes, and how to take tests. Homework assignments also were given. Sample study skills lessons are available by contacting the author.

The chess instruction component focused on teaching the basic rules of the game, learning algebraic chess notation, and analyzing classic chess games. In addition, Bain's (1993) text on chess tactics for students which teaches basic chess tactics as pins, back rank combinations, knight forks, double attacks, discovered checks, and double checks was used each class to teach a new tactic. In addition, homework assignments on tactics were given. In addition, a final chess test using these tactics was given.

Chess instruction also included a competitive component where students played each other throughout the last five weeks of the class. A final class chess rank also was obtained based on the number of wins, draws, and loses.

The final grade for the class was a combination of the study skills instruction assignments and tests with the chess instruction assignments and final test.

We had hoped to have two study skills classes, one that received chess and another that did not. Due to faculty teaching loads that changed at the beginning of the block to just one class, we were not able to have the study skills with no chess class; thus we can not generalize results of this study to that group.

The no study skills and no chess group was our control group of students who were taking either a Geology or History class during this block. No member of this group had any prior chess knowledge or training in study skills. The same teacher taught all three classes.

Our third group, prior chess instruction, was comprised of those students in the Geology or History classes who had taken a few weeks of chess instruction during the preceding Block 3. During Block 3, we field tested different aspects of the chess curriculum in order to prepare for the Block 4 study. Thus, we did not want these students contaminating the results of the Block 4 study.

Instruments

All pretest measures were administered the first two days of Block 4 instruction and all posttest measures were given the last two days. As immediate pre and posttest measures during Block 4, we obtained standard scores, as our main dependent variables, on the three subtests of the Wide Range Achievement Test (WRAT3): Reading, Spelling, and Arithmetic. For the pretest, the Blue Form of the WRAT3 was administered. For the posttest, the Tan Form was given. Both forms are standardized on a *M* = 100 and *SD* = 15. Student standard scores were used in all analyses.

Also, we administered the Group Assessment of Logical Thinking (GALT) as a pre and posttest measure. Possible scores on the GALT range from 0-12. As a posttest only measure, the Watson-Glaser Critical Thinking Appraisal, Form A was administered. We were limited in time for the posttests and only partial data was obtained on a smaller subset, *n*=35, than the original sample. Total raw scores were used in all analyses with a possible range from 0-80.

All scoring of the WRAT3, the GALT, and the Watson-Glaser was conducted using a blind procedure so that the scorer was unaware of student group membership.

In addition, we administered to the chess and study skills class a final chess test; its range was 0-120 points. We obtained their class chess ranking based on games played with each other, possible rank range was 1-23. Also, we obtained the final grade for each class, range was *A* through *F*, coding was a 12 for an *A*, 11 for an *A*-, 10 for a *B*+, and so on, to a 1 for an *F*.

For the demographic variables, sex was coded as a 1 for males and a 2 for females. Grade level was coded as 9, 10, 11, or 12. Age was coded from 14 to 20. Finally, type of instruction was coded as a 3 for the study skills and chess group, a 2 for the prior chess group, and a 1 for the no study skills and no chess group.

Results

Means and standard deviations for the three pretest and posttest measures of the WRAT3 and the GALT, and posttest scores for the Watson-Glaser are presented in Table 1 stratified by type of instruction, total group, sex, and grade. Since pretest scores varied among the groups we calculated post-pretest gain scores for all students for the three WRAT subtests and the GALT. The intercorrelations among all measures with type of instruction, grade, sex, and age are presented in Table 2. For all analyses an alpha level of .05 was used; 28 correlation pairs reached statistical significance.

Achievement data

For our main analyses, we used *t* tests on the posttest-pretest gain scores comparing the three classes on each of the three WRAT3 measures, Reading, Spelling, and Arithmetic. We also combined the two classes, no chess and study skills group with the prior chess group, and compared results to the chess and study skills group.

The assumption of homogeneity of variances was calculated using the F_{max} test for Reading, Spelling, and Arithmetic gain scores for the three groups. The assumption of homogeneity was met at the following levels: F_{max} (3, 20) = 1.28, $p > .05$ for Reading, F_{max} (3, 20) = 3.28, $p > .01$ for Spelling, F_{max} (3, 20) = 2.15, $p > .05$ for Arithmetic. To determine the degree of normality in the gain score data, the Kolmogorov-Smirnov statistic was calculated for each of the three tests. The assumption of normality was met at the following levels: $D = .90$, $p > .05$ for Reading, $D = 1.01$, $p > .01$ for Spelling, and $D = .81$, $p > .05$ for Arithmetic.

For the WRAT3 Reading gain score analyses, the study skills class compared to the no study skills group was statistically significant, $t(39) = 2.77$, $p = .009$, while the comparison with the study skills class with the prior chess group approached significance, $t(38) = 1.88$, $p = .068$. The no study skills group comparison with the prior chess group was not statistically significant, $t(37) = 0.59$, $p = .56$. Combining the two latter groups as one control group and comparing results to the study skills class obtained statistical significance, $t(58) = 2.68$, $p = .01$. The chess and study skills class had a mean gain score of 5.3 points compared to a mean gain score for the other two groups of 1.0 on Reading achievement gain scores.

For the WRAT3 Spelling gain score analyses, no group comparison obtained statistical significance. The study skills class compared to the no study skills group was not significant, $t(39) = 0.22$, $p = .83$, nor was the study skills class comparison with the prior chess group, $t(39) = 1.44$, $p = .16$. The no study skills group comparison with the prior chess group was not statistically significant, $t(38) = 1.05$, $p = .30$. Combining the two latter groups as one control group and comparing results to the chess and study skills class did not obtain statistical significance, $t(59) = 0.88$, $p = .38$. Although not statistically significant, the study skills class had a mean Spelling gain score of 1.48 compared to 0.15 for the other two combined groups.

For the WRAT3 Arithmetic gain score analyses, the study skills class comparison with the no study skills group was not significant, $t(39) = 1.35$, $p = .18$, while the comparison with the study skills class and the prior chess group was statistically significant, $t(39) = 3.87$, $p = .000$. The no study skills group comparison with the prior chess group was significant, $t(38) = 2.59$, $p = .014$. Combining the two latter groups as one control group and comparing results to the study skills class obtained statistical significance, $t(59) = 2.98$, $p = .004$. The study skills class had a mean gain score of 4.76 points compared to a mean gain score for the other two groups of -0.68 on Arithmetic achievement gain scores.

Logical thinking data

For the GALT gain scores the assumption of homogeneity of variances was not met, F_{max} (3,20) = 4.57, $p < .01$. Nor was the assumption of normality met, $D = 1.33$, $p < .01$. Visual inspection revealed that the study skills class had a significant number of gain scores dispersed closer about the mean as compared to the other two groups. No statistical significance was obtained on any group comparison using GALT gain scores. Mean gain scores varied by only 0.43 among the three groups. Results between the study skills class and the no study skills class were, $t(37) = 0.78$, $p = .44$; study skill class results compared to prior chess group were, $t(36) = 0.80$, $p = .43$. The no study skills comparison with prior chess was, $t(37) = 0.04$, $p = .964$. Combining the latter two groups and comparing results with the study skills group obtained, $t(56) = 0.83$, $p = .41$.

For the Watson Glaser posttest scores, homogeneity of variances was met for the three groups, F_{max} (3,20) = 1.44, $p > .05$. The assumption of normality also was met, $D = .89$, $p > .05$. No statistically significant results were obtained between the study skills class and the two groups on mean posttest scores on the Watson Glaser Critical Thinking Appraisal, $t(33) = 1.88$, $p = .25$. Although not statistically significant, the study skills class had a mean score of 39 compared to 35.6 for the two combined control groups, a 3.4 point mean difference.

Canonical Correlation Analysis

We conducted an exploratory canonical correlation analysis to determine which subset of the following independent variables, type of instruction, final class grade, Watson Glaser posttest scores, and GALT gain scores, accounted for the greatest variability in the WRAT3 gain scores for Reading, Spelling, and Arithmetic. Stevens (1986) recommends at least 20 times as many cases as variables to minimize the chances of a Type II error. For exploratory purposes we were willing to accept the Type II error, rather than commit a Type I error in order to look at the canonical relationships. He also discussed that if strong canonical correlations exist in the data, then even relatively small samples (e.g., $n = 50$) will detect them most of the time. Thus, with a total n of 78 and using mean substitution for empty cells, we obtained the following canonical results.

As presented in Table 3, Rao's F-Statistic with successive roots removed revealed one statistically significant root, $F(12\ \&\ 193.4) = 2.23$, $p = .012$. A canonical correlation of .426 was obtained between the weighted sums of the two sets of variables with a canonical R-Squared of .181. With the first root removed, each successive root will explain a unique additional proportion of variability in the two sets of variables since extracted roots are not correlated with each other. The second analysis approached statistical significance, $F(6 \& 148) = 1.83$. $p = .097$. A canonical correlation of .315 and a canonical R-Squared of .099 were calculated. Mendoza, Markos, and Gonter (1978) found that this testing procedure of removing successive roots will detect strong canonical correlations most of the time with similar small samples of 50.

Table 4 presents the standardized coefficients for the three canonical variables. These coefficients present the unique contributions of the respective variables within each canonical variate. For the first canonical variate, final class grade = .638, Watson Glaser posttest = .551, and type of instruction = .535 helped define Arithmetic = .871 and Reading = .381, gain scores. For the second canonical variate, type of instruction = .567 and final class grade = -.677 best defined Reading gain score = .898.

Table 5 presents the canonical factor loadings which pertain to the overall correlation of the original variables with the canonical variates. It also presents the proportion of total variance extracted and the redundancy measures. These canonical factor loadings show us how each variable in each set uniquely contributes to the respective canonical variate. Variables that are highly correlated with a canonical variate have more in common with it. In other words, canonical factor loadings represent simple overall correlations while the standardized coefficients in Table 4 represent the unique contribution of each variable. For the first canonical variate, final class grade = .614, type of instruction = .559, and Watson Glaser posttest = .546 best defined Arithmetic = .918 and Reading = .444, gain scores. The proportion of total variance explained in the first set was 25% with a redundancy of .045. The proportion of variance explained in the second set was 36.5% with a redundancy of .066.

For the second canonical variate, type of instruction = .602 and final class grade = -.694 best defined Reading gain scores = .879. The proportion of total variance extracted was 26.9% by the first set with a redundancy of .027. The proportion of variance extracted by the second set was 33.3% with a redundancy of .033.

Discussion

We conservatively presented a nondirectional hypothesis that significant differences will exist among the three levels of instruction on achievement and logical thinking measures. It was unclear whether a 50 hour, nine week class in chess and study skills instruction was sufficient to produce an effect on achievement tests scores.

Statistically significant positive gains were obtained by the study skills and chess class in reading and arithmetic as compared to the other two groups. In addition, a trend toward significance by the study skills and chess class was observed in spelling and critical thinking.

As an exploratory analysis, results of the canonical correlation revealed additional relationships to consider. The first pair of canonical variates ($p = .012$) suggests that the most salient dimension of the relationship in this high school sample with arithmetic and reading achievement involves a combination of good classroom grades, increased logical thinking, and participation in the study skills and chess instruction group.

The second pair of canonical variates ($p = .097$) suggests that reading achievement is positively related to participation in the study skills and chess instruction and negatively related to final class grade. Subsequent research will examine these relationships with a greater number of students and a longer period of instruction than the nine week block used.

In addition, study skills topics were limited due to the length of the class and the chess instruction. Although we were able to instruct in organizational skills, how to read a chapter, how to spell and understand words better, how to take notes, and how to take tests, a semester long class would allow additional study skill topics to be discussed such as learning styles, time management, how to take notes from books, how to remember information, how to fill in gaps in learning, and how to do better in math and science.

Based on our observations, we recommend that this type of study skills class be made an elective rather than mandatory. Those who did not want to be in the class, but were because of the random assignment, did poorly, going through the motions, and doing the minimum, both in terms of study skills assignments and learning chess. This was reflected in their achievement measures, chess measures, and overall grade for the course. If we had a class of everyone who chose to be in it, we would predict greater achievement gains as a group, even in a nine week course.

Results were positive and unanticipated as we were unsure whether a nine week class would produce the results obtained. A semester long course should produce additional significant gains. Also, given the lack of time to administer posttests and the limited total time available for instruction, the results are strongly encouraging.

Of course, we cannot generalize results of this study to a study skills course without chess instruction. Due to faculty teaching loads changing at the last moment, we were not able to offer this class during Block 4. Subsequent research will stratify this level of instruction into the study. Also, subsequent research will analyze the effects of instruction on broader measures of achievement such as the SAT9 test that is state mandated to be administered annually.

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