

OUR MOVE: USING CHESS TO IMPROVE MATH ACHIEVEMENT FOR STUDENTS WHO RECEIVE SPECIAL EDUCATION SERVICES

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This causal-comparative study evaluated a 30-week chess instructional program implemented within special education math classes for students in the sixth, seventh, and eighth grades in a suburban middle school located in the southwestern United States. An analysis of covariance (ANCOVA) was utilized to compare the adjusted means for the comparison and treatment groups on the students' math achievement as measured by end-of-year course grades and state assessment scores, the Texas Assessment of Knowledge and Skills (TAKS). Pretest scores and grade levels served as covariates. Results indicated a significant difference on four of the measures in favor of the treatment group: end-of-year course grades, overall TAKS math scale scores, and percentage scores on two specific TAKS math objectives: Numbers, Operations, and Quantitative Reasoning and Probability and Statistics. No significant differences were found between the groups on the other four TAKS math objectives: Patterns, Relationships, and Algebraic Reasoning, Geometry and Spatial Reasoning, Concepts and Uses of Measurement, and Underlying Processes and Mathematical Tools. Causation and generalizability are difficult due to the narrow scope of this study. However, these results are encouraging and suggest chess is a potentially effective instructional tool for students who receive special education services in math.

Students who receive special education services have consistently performed poorly on standardized tests when compared to their non-disabled peers (Barkley, 2007; Deshler, et al. 2004). Indeed, the Center on Education Policy (2009) found the differences in test performance between students with disabilities and their non-disabled peers remains very large. In analyzing state test score trends across the nation from 2006 through 2008, the researchers found that the difference in the percentage of students meeting standards of proficiency often exceeds 30 to 40 percentage points in reading and math. The same holds true in the state of Texas.

According to Texas's Academic Excellence Indicator System (AEIS), there has been a significant achievement gap in passing rates on the state math assessment, the *Texas Assessment of Knowledge and Skills* (TAKS), between students who received special education services and the overall population (TEA, 2003, 2004, 2005, 2006, 2007, 2008, 2009a). As Table 1 illustrates, this achievement gap has persisted over the years and widens as the students advance in grade level. For example, from 2003 to 2009 an average of 85.6% of all 3rd graders in Texas passed the math TAKS compared to 79.6% of all 3rd graders receiving special education services (a gap of 6 percentage points), an average of 74.1% of all 7th graders in Texas passed the math TAKS compared to 53.3% of all 7th graders receiving special education services (a gap of 19.4 percentage points), and in the 11th grade this achievement gap rose to 35.4 percentage points (79.4% of all students passed compared with 44.0% of students receiving special education services).

**Table 1. Average Percentage of Students Meeting Math TAKS Standards from 2003 to 2009
(English version, First Administration Only)**

Grade	Overall	SPED	Achievement Gap
3	85.6	79.6	-6.0
4	86.0	79.0	-6.7
5	84.0	74.6	-9.4
6	79.4	61.9	-16.1
7	74.1	53.3	-19.4
8	72.0	49.0	-23.0
9	62.6	32.9	-29.7
10	65.6	33.6	-32.0
11	79.4	44.0	-35.4

Given the pressure and ramifications of increased standards and the accompanying high-stakes testing, some special educators and researchers question whether traditional instructional methods for students with learning disabilities are appropriate and adequate (Bottge, Rueda, Kwon, Grant, & LaRoque, 2009). Several gains have been made for these students, but Bottge et al. point out that only a few studies have identified practices that promote effective math instruction for students who receive special education services in inclusive, reform-oriented settings. The researchers emphasized that more research is needed to show how these approaches can be used in addition to or embedded in the general education curricula.

Mastropieri et al. (2006) also argued that the type of curriculum employed could play an important role in teaching students with disabilities in special classes and inclusive classes alike. Textbook-based curriculums typically place high demands on students' language, literacy, and memory skills. Students with learning disabilities and other special needs do not learn easily under this approach. On the other hand, activities-oriented (or inquiry-oriented) approaches minimize language and literacy requirements. Activities-oriented approaches emphasize hands-on experiences and inquiry rather than memory for text and vocabulary information. Through a series of related quantitative, qualitative, and mixed-method studies, Mastropieri, Scruggs, and Magnusen (1999) found that activity-based approaches to science education could produce *powerful learning and affective effects for students with disabilities* (p. 248). The game of chess can be used as an activity-based approach to enhance learning.

Storey (2000) strongly advocated that educators consider utilizing the game of chess as an instructional strategy for students receiving special education services to reinforce such skills as (a) concentration, (b) problem identification, (c) problem-solving, (d) planning strategies, (e) creativity, and (f) lucid thinking. He noted that students with disabilities are often not strategic learners and found that chess can tangibly demonstrate to students the rewards of study and practice and that chess can be used as a vehicle for teaching students the process of solving a problem. Indeed, Bulgren, Deshler, and Lenz (2007) also pointed out that students who receive special education services often focus on irrelevant or only remotely relevant content rather than on what is truly important. Chess instruction can provide a means of teaching students to focus on what is important in a given situation.

Chess and Math Education

As stated by Root (2008), the game of chess *is an authentic context for students' mathematical problem-solving* (p. 2). Indeed, mathematics professor David Robitaille (1974) noted that there are numerous mathematical problems associated with the game of chess and with chessboards. Ho (2006) elaborated on the different kinds of mathematical chess puzzles that can be produced and their potential benefits for learning outcomes. He proffered that chess symbols used directly in arithmetic operations can transform simple, one-step questions into abstract and symbolic multi-step questions that require children to analyze the problem and take the necessary steps to understand the concept before coming up with a solution. For example, Ho substituted chess symbols (images representing the pawns and pieces) for numbers in mathematical equations. Since each pawn and chess piece is proscribed a number value, students could solve the equation using the chess symbols to represent different numeric values.

Hong and Bart (2007) examined the cognitive effects of chess instruction on students at risk for academic failure. Thirty-eight students, ages 8 to 12, from three elementary schools participated in this study. The schools were located in Seoul, South Korea. Both groups were administered *The Test of Nonverbal Intelligence – Third Edition (TONI-3)* and *The Raven's Progressive Matrices Test (RPM)* as

pre-tests. The experimental group received twelve, 90-minute chess lessons once per week for three months and the control group students attended regular school activities during that time. Each chess lesson included three segments: reviewing, lecturing, and chess playing. These lessons were derived from Pelts and Albert's *Comprehensive Chess Course* (as cited in Hong & Bart). At the end of the chess intervention the participants were again given the TONI-3 and the RPM. The experimental group also took a chess quiz developed by the instructor to measure student knowledge of chess pieces and their moves. A repeated measure ANOVA with a 2X2 factorial design was employed to determine whether chess instruction would influence the experimental group's scores on the TONI-3 and the RPM. The results of this analysis found no significant difference between these two groups on either measure of cognitive abilities.

Following this statistical procedure, a partial correlation analysis was used to explore relationships among pre-test and post-test scores, chess skill ratings, chess quiz scores, and chess practice for participants in the experimental group. This analysis found that the chess skill rating and the TONI-3 post-test score were significantly correlated when controlling for the pre-test score. According to the researchers, this finding suggested that chess skill rating is a key predictor for the improvement of student cognitive skills. Students at risk of academic failure who are at beginning levels of chess competency may be able to improve their cognitive skills and their skills at chess. The researchers note two major limitations with this study that may account for the lack of significance with cognitive effects: (a) the twelve-session instruction period may have been too brief; Bart's study (as cited in Hong and Bart, 2007) suggested at least one whole academic year and preferably two, if possible, (b) the chess instruction was not developed specifically for students at risk of academic behavior; it was likely that deeper levels of chess knowledge needed to be acquired in order for higher levels of nonverbal intelligence and other cognitive abilities to be attained.

Scholz et al. (2008) focused their study on relatively specific, sequential transfer of chess training to two domains: concentration and basic math skills. Another aim of this study was to evaluate the feasibility of chess lessons in their schools, including the practicality of developed chess-teaching material and for non-chess playing teachers and the chess playing abilities of children after one year of teaching. The purpose of this study was to evaluate the benefit of chess in mathematics lessons for children with learning disabilities. Seven classes at four schools for children with learning disabilities were selected. The study was initiated in seven classes at four such schools in Leipzig, Germany and its surrounding area with third and fourth graders (two classes at each school except for one with only one class). The duration of the chess intervention was one year. In the schools with two classes, one class was randomly selected as the experimental class and the other as the control class. At the school with only one class, it also served as an experimental class. The experimental classes each received one hour of chess lessons per week in place of one hour of mathematics lessons. Participants were given pre-test and post-test measures of calculation abilities and concentration abilities. Fifty-three students participated in both tests and were eligible for analysis for this study: 31 in the experimental group and 22 in the control group. The results of these measures were analyzed by ANCOVA with the pre-test measures and school as covariates. The researchers found that the students who received weekly chess lessons scored significantly higher on the post-test measure for basic math skills such as counting and addition. Regarding the concentration measure, the researchers found no significant difference between the two groups. The results of this study suggested that there was a sequential, low road transfer of chess skills to basic mathematics skills for students with learning disabilities. Additionally, the process of the study went without any problems and proved to be feasible for both the teachers with no prior chess knowledge and the students. The researchers concluded that chess as an element of mathematics lessons for children with learning disabilities could be a valuable learning tool.

Purpose of the Study

The purpose of this study was to explore the use of the game of chess as an intervention for improving math achievement with students who receive special education services. There is a current emphasis for higher math achievement in public education in America overall. Similarly, there is an emphasis for increased math performance with students with learning disabilities and special needs. The game of chess offers an intriguing potential for its use with students who receive special education services. Traditionally viewed as a game for intellects only, this ancient and international game contains many benefits that mirror effective interventions for these students. It is a tactile, activity-oriented endeavor that promotes critical thinking and lends itself to self-directed learning. While much of the accolades of the benefits of chess in education are anecdotal (Lipshultz, 2009; MacEnulty, 2007), there is enough

empirical evidence to support its exploration with high needs populations (Eberhard, 2006; Scholz et al., 2008). This ex-post facto study examined an intervention implemented at a middle school in a suburban district in the southwestern United States. In order to explore the success of this 30-week program a causal comparative design was employed. Despite its limitations, this study does offer some insight, evidence, and fodder for the further exploration of the game of chess as a tool for enhanced math achievement.

Method of Procedure

Similar to Scholz et al. (2008), this ex-post-facto study was designed to evaluate the effectiveness of a chess-math intervention implemented in resource math classes at a middle school campus. This study also corresponds to the recommendation of Hong and Bart (2007) as the intervention was implemented on a weekly basis for five of the six grading terms throughout the academic year. The use of chess instruction as a weekly intervention has been found to be successful in past studies (Eberhard, 2006; Rifner, 1992; Scholz et al., Smith & Cage, 2000). To best assess its effects a causal-comparative study was initiated comparing the math achievement of the students in the treatment classes with the math achievement of students from comparable classes.

Design

In this causal-comparative design, one middle school implemented chess instruction once per week for 30 weeks to augment the math curriculum known as the *Texas Essential Knowledge and Skills* (TEKS). Within the same district, the middle school with the closest demographics and characteristics of students was selected as the comparison group. As Schenker and Rumrill (2004) explained, a causal-comparative design is useful for studies examining differences between intact groups not amenable to treatment manipulation.

For this study, the independent variable was chess instruction. The chess instruction consisted of a weekly chess lesson which supplanted the general math lesson for that class period. The chess lessons focused on teaching the rules of the game, strategies, and tactics and were connected to math objectives. The dependent variable was math achievement. The dependent variable was measured by student scores for (a) the end-of-year course grades in resource math in 2008 and 2009, (b) the Math TAKS for 2008 and 2009 (first administrations only), and (c) each of the six Math TAKS objectives for 2008 and 2009 (first administrations only).

The following hypotheses were tested at the $\alpha = 0.05$ levels of significance:

1. There is a significant difference in end-of-year course grades between students in resource math classes who received weekly chess instruction and students in resource math classes who did not receive weekly chess instruction.
2. There is a significant difference in the math TAKS scale scores between students in resource math classes who received weekly chess instruction and students in resource math classes who did not receive weekly chess instruction.
3. There is a significant difference in percentage scores on the six math objectives measured by the math TAKS test between students in resource math classes who received weekly chess instruction and students in resource math classes who did not receive weekly chess instruction.

Instrumentation

The dependent variable was measured in three ways: (a) the students' percentage scores for the end-of-year course grades in resource math, (b) the students' overall scale scores on the Math TAKS test, and (c) the percentage scores on each of the six objectives on the Math TAKS test. The end-of-year course grades were the final average of the students' mastery of Independent Education Program (IEP) goals and objectives in resource math for the entire academic year. These percentage scores reflected the students' mastery of their IEPs, which were based upon the grade level TEKS. According to the school district's policy, grades for resource classes were determined based upon students' progress toward mastery of their individualized goals and objectives. Additionally, students' mastery levels were individualized for each objective. Weekly averages were calculated for each objective. For example, if a student's IEP stipulated 60% as the mastery criterion for the math objective titled Concepts and Uses of Measurement, then 60 would have been used as the denominator when the teacher calculated grades for this student on this objective. Thus, if this student's progress for the week on Concepts and Uses of Measurement was 53%, then 53 would have been divided by 60 and the resulting weekly progress grade

for Concepts and Uses of Measurement would have equaled 88. At the end of each grading period, the teacher averaged the grades by objective. The resulting score was reported as the student's grade for that term. A student could not receive a grade higher than 100.

The *Texas Assessment of Knowledge and Skills* (TAKS), *Texas Assessment of Knowledge and Skills-Accommodated* (TAKS-A), *Texas Assessment of Knowledge and Skills-Modified* (TAKS-M), and *Texas Assessment of Knowledge and Skills-Alternate* (TAKS-Alt) were standardized assessments given each spring to all students enrolled in public school in Texas from grades 3 to 11 in several subjects. The TAKS was designed to measure students' mastery of the state-mandated curriculum, the *Texas Essential Knowledge and Skills* (TEKS), and their ability to apply these defined knowledge and skills at each tested grade level (TEA, 2009b). As defined by TEA, *TAKS measures a student's mastery of the state-mandated curriculum, the TEKS. All eligible Texas public school students are assessed in mathematics in grades 3-10 and exit level* (TEA, p. 5).

The TAKS-A was an accommodated version of the TAKS. It was designed for the assessment of students receiving special education services who met participation requirements. It utilized the same test questions without field test items and a format featuring larger font and more white space. Additionally, students were allowed to use more educational accommodations that were part of their IEP (TEA, 2009b). The TAKS-M test was defined by TEA as an alternate assessment based on modified academic achievement standards and is designed to meet the requirements of federal law. TAKS-M is intended for a small number of students receiving special education services who meet participation requirements. Each test covers the same grade-level content as TAKS, but TAKS-M tests have been changed in format (larger font, fewer items per page, etc.) and test design (fewer answer choices, simpler vocabulary and sentence structure, etc.). (p. 5)

For the purpose of this study, the term TAKS applies to all versions of the state assessment. The TAKS-Alt version was not an included instrument in this study. The results for all three versions of the TAKS assessments incorporated within this study are reported utilizing scale scores. For all grade levels and subjects a scale score of 2100 was set as the minimum standard for a student to demonstrate mastery of the TEKS. A scale score of 2400 was the standard for all tests and grade levels for a student's performance to be considered commended. Additionally, as a requirement of the Student Success Initiative (SSI) all students in the 5th and 8th grades were required to meet the minimum standard on the math TAKS as part of the criteria for promotion to the next grade level. Students who scored below 2100 were mandated to test again. Students were allowed to take the test up to three times in order to meet the standard. For the purpose of this study only scale score results from the student's first administration of the exam were collected.

The reliability of the TAKS assessments were tested annually with the use of field tests and field test questions imbedded within the assessments. Measurement for internal consistency utilized the Kuder-Richardson 20 and yielded alpha co-efficients ranging from 0.81 to 0.93 (Garcia, 2008). The TEA also took extensive measures to ensure the content validity of each TAKS assessment. The test itself was a criterion-based assessment. For mathematics, the TAKS consisted of word problems with multiple answer choices.

All 16 students in the comparison group took the TAKS-M version of the state assessment in both 2008 and 2009. For the treatment group, 11 students took the TAKS-M version of the state assessment in both 2008 and 2009. Three students took the TAKS version of the state assessment in 2008 and the TAKS-M version in 2009. One student took the TAKS version of the state assessment in 2008 and in 2009.

Participants

The Texas Education Agency collects data through the Public Education Information Management System (PEIMS) four times each school year following a schedule established by the PEIMS Data Standards (TEA, n.d.). For the 2008-2009 academic year, fall data include snapshot data that *reflect the status of the district on Oct. 31, 2008. These data include budget, staff, [and] organization and student data.* (TEA, ¶ 2). In accordance with this standard, this study utilized this date as the date of enrollment for student data included in this study.

Participants of this study consisted of sixth, seventh, and eighth grade students from two middle schools in a suburban school district located in the southwest United States. On both campuses, the classes were

comprised of sixth, seventh, and eighth grade students together. Prior to the study, initial approval was obtained by the participating school district's institutional review board (IRB); followed by approval from the university's IRB.

End-of-year course grades and TAKS scores were analyzed from middle school students enrolled in resource math on both the treatment and comparison campuses during the 2008-2009 academic year. Only scores from students enrolled on the TEA snapshot date of October 31, 2008, through the last day of school, June 5, 2009, were examined. The sample size consisted of a total of 31 participants (16 students at the comparison campus and 15 at the treatment campus) in the sixth, seventh, and eighth grades. According to Gall, Gall, and Borg (2007), *in causal-comparative and experimental research, there should be at least 15 participants in each group to be compared* (p. 176).

Students identified as part of the treatment group were those students enrolled in resource math classes that exposed students to weekly chess instruction on or before October 31, 2008, through the end of the school year June 5, 2009 and who were in attendance for a minimum of 80% of the chess lessons. These students received instruction in the standard math curriculum that was individualized to meet the goals and objectives of each student's individualized education program (IEP). One day a week for 30 weeks (out of 36 total instructional weeks) these students received chess instruction instead of the standard math curriculum

The students identified as part of the comparison group were those students enrolled in resource math classes on or before October 31, 2008, through the end of the school year June 5, 2009, at the comparison campus. These students received instruction in the standard math curriculum that was individualized to meet the goals and objectives of each student's individualized education program (IEP). These students did not receive chess instruction.

A total of 31 students comprised the sample for this causal-comparative study. The comparison group consisted of 16 middle-school students: 6th graders = 2 (13%), 7th graders = 8 (50%), and 8th graders = 6 (38%). The treatment group consisted of 15 middle-school students: 6th graders = 4 (27%), 7th graders = 6 (40%), 8th graders = 5 (33%). Table 2 displays the demographics for the participants by gender, ethnicity, and socio-economic status as well as by the students' primary disability diagnoses. All 31 students were diagnosed with a disability that qualified them for special education services; six of these students were also diagnosed with a secondary disability.

Regarding the students' primary disabilities, the comparison group was composed of 4 students (25%) diagnosed as Other Health Impaired, 1 student (6%) diagnosed as Auditory Impaired, and 11 students (69%) diagnosed with a Specific Learning Disability. For the treatment group, 6 students (40%) were diagnosed as Other Health Impaired, 2 students (13%) were diagnosed with an Emotional/Behavioral Disorder, 5 students (33%) were diagnosed with a Specific Learning Disability, and 2 students (13%) were diagnosed with Autism.

Regarding the students' secondary disabilities, a total of six students in both groups were diagnosed with an additional disability. Two students in the comparison group were diagnosed with a Speech Impairment as a secondary disability. Four students in the treatment group were diagnosed with secondary disabilities: one as Other Health Impaired and three with a Specific Learning Disability.

All 16 students in the comparison group took the TAKS-M version of the state assessment in both 2008 and 2009. For the treatment group, 11 students took the TAKS-M version of the state assessment in both 2008 and 2009. Three students took the TAKS version of the state assessment in 2008 and the TAKS-M version in 2009. One student took the TAKS version of the state assessment in 2008 and in 2009.

Procedures

All schools in Texas keep records of students' progress by grades and on the state assessment tests (e.g., TAKS). In order to provide anonymity for the participants and to comply with the *Family Education Rights and Privacy Act* (FERPA), the registrar for each campus was responsible for retrieving the student data for the researcher. The researcher trained the campus registrars on the protocols for reporting the data and for coding the students for anonymity. Each student was coded for anonymity by the registrar. The data reported for each coded student listed their end-of-year course grades in resource math for 2008

and 2009; their overall scale scores on the math TAKS for 2008 and 2009, and their math TAKS percentage scores by objective for 2008 and 2009.

Table 2. Background of Participants

	Comparison Group (n=16)	Treatment Group (n=15)	Total (n=31)
Female	6 (38%)	5 (33%)	11 (35%)
Male	10 (63%)	10 (67%)	20 (65%)
African American	5 (31%)	5 (33%)	10 (32%)
Hispanic	5 (31%)	4 (27%)	9 (29%)
White	6 (38%)	6 (40%)	12 (39%)
Economic Disadvantaged	10 (63%)	6 (40%)	16 (52%)
Other Health Impaired	4 (25%)	6 (40%)	10 (32%)
Auditory Impaired	1 (6%)	0 (0%)	1 (3%)
Emotional/Behavioral Disorder	0 (0%)	2 (13%)	2 (6%)
Specific Learning Disability	11 (69%)	5 (33%)	16 (52%)
Autism	0 (0%)	2 (13%)	2 (6%)

On the treatment campus, the resource math classes were taught in two different class periods and consisted of students in the 6th, 7th, and 8th grades. Each student was taught the grade level TEKS in accordance with his or her IEP by a classroom teacher certified in special education and a paraprofessional teaching assistant. The classroom teacher, who was in her 2nd year of education, and the paraprofessional teaching assistant were responsible for teaching the math curriculum and implementing the appropriate accommodations.

During the beginning of the school year, the teacher and the researcher developed lesson plans that both incorporated chess instruction and met the mathematics TEKS outlined in the students' IEPs. Keeping the Perkins and Salomon's (1989) principles of low road, sequential transfer at the forefront, the individualized lesson plans were specifically designed to use chess instruction as a tool for transfer. The chess curriculum was derived primarily from Garry Kasparov's (Khmelnitsky, Khodarkovsky, & Zadorozny, 2006a, 2006b) and David MacEnulty's (MacEnulty, 2006) chess curriculums. Additionally, lessons and activities were derived from Alexey Root's works, *Science, Math, Checkmate* (2008) and *Children and Chess* (2006). These individualized chess lessons were taught each Friday for 30 weeks during the students' normal math class periods. The class periods lasted approximately 50 minutes. The teacher began the weekly chess instruction on the first Friday of the second grading term during the 2008-2009 academic year: October 10, 2008. The lessons were taught on each subsequent Friday through the end of the school year, June 5, 2009. During each of these 30 class periods, students were given the option of participating in the chess lesson or a traditional math lesson. As reported by the classroom teacher, all participants opted for the chess lesson each week.

Neither the classroom teacher nor the paraprofessional teaching assistant possessed much prior knowledge of the game of chess; both reported being only vaguely familiar with the game and its rules. Similarly, the students in the treatment classes possessed minimal prior chess knowledge. An informal survey conducted by the math teacher prior to the chess lessons revealed that ten students reported having never played the game before, two students reported having played once or twice in their lives but did not really know the rules, and three students reported having played several times in their lives and were familiar with the basic rules. Thus, the chess lessons were designed to be taught (and learned) without pre-requisite chess knowledge. Indeed, an implicit aim of this study, similar the aim of Scholz et al. (2008) and a need emphasized by Eberhard (2006), was to explore the feasibility of the implementation of the chess instruction by educators and students who were not well versed in the game of chess. The comparison group was comprised of three resource math classes on the campus that most resembled the treatment campus demographically. This school was located 1.7 miles from the treatment campus and also served students in the 6th, 7th, and 8th grades. The classroom teacher and a paraprofessional teaching assistant were responsible for teaching the math curriculum and implementing the appropriate accommodations. These students were taught the mathematics TEKS according to their IEP goals and objectives. The classroom teacher was also in his 2nd year of education. This teacher did

not utilize chess as a pedagogical tool. It should be noted that unlike the treatment campus, this campus had an active chess club. To control for possible confounding variables, the students enrolled in the comparison class who played chess were expunged from the data by the campus registrar.

Results

In order to test the hypotheses for this study, an analysis of covariance (ANCOVA) was conducted to compare the adjusted mean scores for each of the three dependent measures. In accordance with Scholz et al. (2008), the students' grade level and pretest scores served as covariates to control for error variance. In order to reject the null hypotheses and accept the research hypotheses, *F* ratios were measured at the $\alpha = 0.05$ levels of significance. With data from 31 participants eligible for analysis, the cutoff score for the *F* distribution was 4.17.

The design of this study measured math achievement with two forms of instrumentation: the end-of-year course grades in resource math and the math TAKS. There were eight measures of student achievement that were analyzed: the students' end-of-year course grades in their resource math classes, the students' overall scale scores on the math TAKS, and the students' percentage scores on each of the six mathematics objectives on the TAKS: (a) Numbers, Operations, and Quantitative Reasoning; (b) Patterns, Relationships, and Algebraic Reasoning; (c) Geometry and Spatial Reasoning; (d) Concepts and Uses of Measurement; (e) Probability and Statistics; (f) Mathematical Processes and Tools. These scores were tested at the $\alpha = 0.05$ levels of significance with a critical *F* value (1, 30) = 4.17. Table 3 highlights adjusted mean scores for 2009 measures of math achievement.

End-of-Year Course Grades

The results of this study indicated a significant difference between the end-of-year course grades for students in resource math classes who received weekly chess instruction and students in resource math classes who did not receive weekly chess instruction. Participants' final grades from the 2007-2008 academic year served as the pre-test measure. Prior to an analysis of covariance, Levene's Test of Equality of Variances was calculated. Results were not significant ($F = 0.101$, $p = 0.753$). Thus, the null hypothesis that the error variance of the dependent variable would be equal across groups was accepted; homogeneity across the two groups was assumed. The mean 2008 pre-test scores for the two groups were as follows: the comparison group had a mean final grade of 84.25 (SD = 6.748) and the treatment group 87.53 (SD = 6.379). The 2009 post-test means were 79.94 (SD = 4.582) for the comparison group and 88.73 (SD = 4.891) for the treatment group. Using grade level and pretest measures as covariates, an Analysis of Covariance (ANCOVA) analyzed the adjusted mean scores (comparison = 80.61; treatment = 88.02) for students from the two groups with the $\alpha = 0.05$. Results showed a statistically significant relationship between the independent variable, chess instruction, and the dependent measure, end-of-year course grades ($F = 19.40$; $p < 0.001$).

In order to test the power of the statistical significance, a partial eta squared was calculated yielding a medium sized effect for the independent variable (partial $\eta^2 = 0.418$).

Math TAKS Scale Scores

Significant differences existed between the math TAKS scale scores for students in resource math classes who received weekly chess instruction and students in resource math classes who did not receive weekly chess instruction. Participants' math TAKS scale scores from the spring of 2008 (first administration only) served as the pre-test measure. Prior to an analysis of covariance, Levene's Test of Equality of Variances was calculated. Results were not significant ($F = 0.317$, $p = 0.578$). Thus, homogeneity across the two groups was assumed.

The mean 2008 pre-test scores for the two groups were as follows: the comparison group had a mean scale score of 2097.94 (SD = 119.148) and the treatment group 2126.80 (SD = 152.931). The 2009 post-test means were 2083.75 (SD = 85.106) for the comparison group and 2192.73 (SD = 104.795) for the treatment group. Using grade level and pretest measures as covariates, an Analysis of Covariance (ANCOVA) analyzed the adjusted mean scores (comparison = 2084.75; treatment = 2191.67) for students from the two groups with the $\alpha = 0.05$. Results showed a statistically significant relationship between the independent variable, chess instruction, and the dependent measure, math TAKS scale scores ($F = 9.167$; $p = 0.005$). In order to test the power of the statistical significance, a partial eta squared was calculated yielding a moderate sized effect for the independent variable (partial $\eta^2 = 0.253$).

Table 3. Adjusted Mean Scores for 2009 Measures of Math Achievement

Measure	Comparison	Treatment	<i>F</i>	Significance	Partial η^2
Final Grade 0.418	80.61	88.02	19.398*	p<0.001	
TAKS Scale Score 0.253	2084.75	2191.67	9.167*	p=0.005	
TAKS Objective 1 0.210	36.39	55.32	7.167*	p=0.012	
TAKS Objective 2	44.56	46.80	0.860	p=0.772	0.086
TAKS Objective 3	46.94	59.12	2.368	p=0.135	0.081
TAKS Objective 4	50.82	59.80	1.447	p=0.239	0.051
TAKS Objective 5	45.71	67.38	7.321*	p=0.012	0.213
TAKS Objective 6 0.129	47.94	63.26	3.990	p=0.056	

*indicates significance at $p < 0.05$ levels

Math TAKS Percentage Scores

This study attempted to assess whether significant differences existed between the math TAKS percentage scores by objective for students in resource math classes who received weekly chess instruction and students in resource math classes who did not receive weekly chess instruction. There are six different math objectives measured by the TAKS: (a) Numbers, Operations, and Quantitative Reasoning; (b) Patterns, Relationships, and Algebraic Reasoning; (c) Geometry and Spatial Reasoning; (d) Concepts and Uses of Measurement; (e) Probability and Statistics; (f) Mathematical Processes and Tools. Participants' math TAKS percentage scores by objective from the spring of 2008 (first administration only) served as the pre-test measure. Each objective score was analyzed as a separate measure.

Objective 1: Numbers, operations, and quantitative reasoning.

Levene's Test of Equality of Variances was calculated to reveal no significant differences based upon numbers, operations, and quantitative reasoning ($F = 0.280$, $p = 0.601$). The mean 2008 pre-test scores for the two groups were as follows: the comparison group had a mean percentage score of 50.25 (SD = 17.983) and the treatment group 56.33 (SD = 18.999). The 2009 post-test means were 35.81 (SD = 15.770) for the comparison group and 55.93 (SD = 21.875) for the treatment group. Using grade level and pretest measures as covariates, an Analysis of Covariance (ANCOVA) analyzed the adjusted mean scores (comparison = 55.32; treatment = 36.39) for students from the two groups with the alpha = 0.05. Results showed a statistically significant relationship between the independent variable, chess instruction, and the dependent measure, math TAKS percentage scores on objective 1 ($F = 7.167$; $p = 0.012$). In order to test the power of the statistical significance, a partial eta squared was calculated yielding a moderate sized effect for the independent variable (partial $\eta^2 = 0.210$).

Objective 2: Patterns, relationships, and algebraic reasoning.

Levene's Test of Equality of Variances was calculated and revealed no significant differences based upon patterns, relationships, and algebraic reasoning ($F = 0.449$, $p = 0.508$). The mean 2008 pre-test scores for the two groups were as follows: the comparison group had a mean percentage score of 37.06 (SD = 22.191) and the treatment group 47.87 (SD = 20.525). The 2009 post-test means were 43.94 (SD = 21.650) for the comparison group and 47.47 (SD = 19.500) for the treatment group. Using grade level and pretest measures as covariates, an Analysis of Covariance (ANCOVA) analyzed the adjusted mean scores (comparison = 44.56; treatment = 46.80) for students from the two groups with the alpha = 0.05. Results did not show a statistically significant relationship between the independent variable, chess instruction, and the dependent measure, math TAKS percentage scores on objective 2 ($F = 0.086$; $p = 0.772$).

Objective 3: Geometry and spatial reasoning.

Levene's Test of Equality of Variances was calculated, revealing no significant differences based upon geometry and spatial reasoning ($F = 0.267$, $p = 0.609$). The mean 2008 pre-test scores for the two groups were as follows: the comparison group had a mean percentage score of 49.69 (SD = 27.930) and the treatment group 48.60 (SD = 25.424). The 2009 post-test means were 46.50 (SD = 20.416) for the

comparison group and 59.60 (SD = 22.950) for the treatment group. Using grade level and pretest measures as covariates, an Analysis of Covariance (ANCOVA) analyzed the adjusted mean scores (comparison = 46.94; treatment = 59.12) for students from the two groups with the alpha = 0.05. Results did not show a statistically significant relationship between the independent variable, chess instruction, and the dependent measure, math TAKS percentage scores on objective 3 ($F = 2.368$; $p = 0.135$).

Objective 4: Concepts and uses of measurement.

Prior to an analysis of covariance, Levene's Test of Equality of Variances was calculated revealing no significant differences based upon concepts and uses of measurement ($F = 0.126$, $p = 0.725$). The mean 2008 pre-test scores for the two groups were as follows: the comparison group had a mean percentage score of 45.25 (SD = 26.279) and the treatment group 46.60 (SD = 26.554). The 2009 post-test means were 51.56 (SD = 19.298) for the comparison group and 59.00 (SD = 22.377) for the treatment group. Using grade level and pretest measures as covariates, an Analysis of Covariance (ANCOVA) analyzed the adjusted mean scores (comparison = 50.82; treatment = 59.80) for students from the two groups with the alpha = 0.05. Results did not show a statistically significant relationship between the independent variable, chess instruction, and the dependent measure, math TAKS percentage scores on objective 4 ($F = 1.447$; $p = 0.239$).

Objective 5: Probability and statistics.

Results for probability and statistics were found not to be significant after calculating Levene's Test of Equality of Variances ($F = 0.140$, $p = 0.711$). The mean 2008 pre-test scores for the two groups were as follows: the comparison group had a mean percentage score of 54.25 (SD = 26.459) and the treatment group 64.80 (SD = 21.838). The 2009 post-test means were 45.44 (SD = 20.982) for the comparison group and 67.67 (SD = 21.104) for the treatment group. Using grade level and pretest measures as covariates, an Analysis of Covariance (ANCOVA) analyzed the adjusted mean scores (comparison = 45.71; treatment = 67.38) for students from the two groups with the alpha = 0.05. Results showed a statistically significant relationship between the independent variable, chess instruction, and the dependent measure, math TAKS percentage scores on objective 5 ($F = 7.321$; $p = 0.012$). In order to test the power of the statistical significance, a partial eta squared was calculated yielding a moderate sized effect for the independent variable (partial $\eta^2 = 0.213$).

Objective 6: Underlying processes and mathematical tools.

Levene's Test of Equality of Variances revealed no significant differences ($F = 0.022$, $p = 0.882$) based upon underlying processes and mathematical tools. The mean 2008 pre-test scores for the two groups were as follows: the comparison group had a mean percentage score of 45.50 (SD = 21.282) and the treatment group 60.27 (SD = 27.202). The 2009 post-test means were 48.50 (SD = 19.538) for the comparison group and 62.67 (SD = 19.888) for the treatment group. Using grade level and pretest measures as covariates, an Analysis of Covariance (ANCOVA) analyzed the adjusted mean scores (comparison = 47.94; treatment = 63.26) for students from the two groups with the alpha = 0.05. Results did not show a statistically significant relationship between the independent variable, chess instruction, and the dependent measure, math TAKS percentage scores on objective 6 ($F = 3.990$; $p = 0.056$).

Discussion

The results of this study are predominantly consistent with the research of Eberhard (2006), Ho (2006), Mastropieri et al. (2006), and Scholz et al. (2008) and contribute to the body of knowledge for both the learning needs of students who receive special education services and the use of chess in education in general. This unique study is the first of its kind to study the use of chess with students in special education math classes in the United States. While this causal-comparative design may not speak to causation, it does offer some interesting insight and empirical support to the anecdotal and theoretical assertions of the positive benefits of chess with students in special populations. More research will be needed to further explore this phenomenon and examine it in closer detail.

One point of interest with this study that was similarly acknowledged in Scholz et al. (2008) pertains to the fact that the treatment group, in essence, received less exposure to the general mathematics curriculum (30 instructional days) than the comparison group and yet still was not outperformed on any of the eight measures of math achievement. Indeed, it could be argued that the comparison group held an advantage over the treatment group in that these students received more instructional hours with the traditional mathematics curriculum. Yet, the treatment group still outperformed the comparison group on four of the mathematics achievement measures. While it is difficult to ascertain the precise cause of

these differences given the nature of the design of this study, these findings (similar to Scholz et al.) do, however, suggest that the loss of the regular mathematics lessons could, in the very least, be compensated by the chess lessons. In other words, supplanting one traditional math lesson a week with a chess lesson did not diminish the math achievement of the students in the treatment group. Indeed, it may very well have enhanced their achievement. More research is recommended in this area.

Moreover, an implicit aim of this study, similar the aim of Scholz et al. (2008) and a need emphasized by Eberhard (2006), was to explore the feasibility of the implementation of the chess instruction by educators and students who were not well versed in the game of chess. An informal survey conducted by the math teacher prior to the chess lessons revealed that: ten students reported having never played the game before, two students reported having played once or twice in their lives, but did not really know the rules, and three students reported having played several times in their lives and were familiar with the basic rules. No students reported playing on a regular basis, nor knew all the rules of the game. The teacher and teacher's aid were also only vaguely familiar with the game and its rules. Nevertheless, the teacher reported that the process of the study went without problems and that the chess lessons proved feasible for both the educators and students alike. Furthermore, the teacher reported that the students found the chess lessons engaging and looked forward to them each week.

Regarding the phenomenon of transfer, these findings are consistent with that of Rifner (1992). One of the central issues to the successful use of chess instruction in schools is that of transferability. Rifner addressed the concern of the transferability of chess skills to other academic and life areas. He cited the evidence from De Groot (1965) and Chi, Glaser, and Rees (1981) that suggested that high-level chess skills are domain specific and not readily transferable. Rifner's own study emphasized transfer as an explicit goal of chess instruction and implemented the principles articulated by theorists concerned with transfer of training (Perkins and Salomon, 1989). His results suggested that students were able to transfer skills gained from learning chess to a remote transfer task involving poetic analysis and interpretation. The results of his study indicated that, if methods of teaching for transfer are applied, transfer of training can occur in a real-world classroom setting, even for remote-transfer tasks. Scholz et al. (2008) also focused on low road transfer as an explicit goal for their study. Keeping the principles of low road, sequential transfer at the forefront, this present study was specifically designed to use chess instruction as a tool for transfer. This facet of this study differentiates it from other studies that simply explored the relationship of chess knowledge, chess playing, or isolated chess instruction with academic achievement (Benson, 2006; Garcia, 2008; Hong & Bart, 2007; Korenman, Korenman, & Lyutykh, 2009; Smith & Cage, 2000). The present findings likewise support the conclusion that transfer occurred within the treatment group.

While there are significant findings for this study on four measures of math achievement, it is important to note that the scope of this study was narrow, and thus generalizability is limited. Limitations of this study include small sample size and lack of random assignment. Teacher expectancy effects were likewise unable to be controlled. Furthermore, as Gall et al. (2007) have enumerated, it is difficult to establish causality on the basis of collected data when using an analysis of covariance in a causal-comparative study. Additionally, Schenker and Rumrill (2004) stated, *causal-comparative studies examine the magnitude of differences between or among groups, but no attempt is made to infer causality within an individual study* (p. 117). The results of this study do, indeed, show a significant difference between the two groups on four of the eight measures of math achievement. While it may not be asserted that the chess instruction was a cause of the difference, these results are encouraging and suggest a possible relationship between math achievement and chess instruction. Thus, in accordance with Scholz et al. (2008), Storey (2000), and Wojcio (1995) these researchers conclude that chess as an element of mathematics lessons in classes for students who receive special education services could be a valuable learning tool. Indeed, these results support the further empirical exploration in this realm.

The findings of this study are promising overall. It is recommended that a replication of this study be conducted on a larger scale and with random assignment, if possible. Furthermore, it is recommended to replicate this study at both the elementary and high school levels. Additionally, more research is recommended to explore in detail the underlying factors for the transfer of chess knowledge to mathematical achievement. In addition to these quantitative research recommendations, it is also recommended that qualitative and mixed-method designs explore the affective benefits of chess instruction for students who receive special education services. Further empirical exploration and development of a chess curriculum that is designed for the mathematics classroom is also recommended.

Should more research in this arena provide strong empirical support for chess as an effective instructional tool in math for students who receive special education services, the ramifications would be highly significant for administrators, teachers, and students.

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