
Berkeley Chess School *First Moves*

Year 1 Impact Analysis

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Executive Summary

This interim memo presents the first year findings of the Berkeley Chess School's (BCS) *First Moves* Program on the academic achievement¹ of 2nd, 3rd, and 4th graders in the Oakland Unified School District. The data sources used for this analysis include student-level district data collected by Berkeley Policy Associates directly from Oakland Unified School District (OUSD), a 1-hour focus group with BCS instructors, dosage data² provided by BCS, and three observations of the chess instruction implementation in the classrooms. The student-level district data used in this analysis includes: (1) student demographic data (race/ethnicity, gender, English Learner status, disability status); (2) standardized test scores (CST-Math and ELA); and (3) attendance.

Analysis of the student CST scores of the BCS *First Moves* program group indicates a positive significant impact for students that received more than 20 hours of chess instruction. Specifically, the BCS *First Moves* students who received more than 20 hours of chess instruction had significantly higher CST-Math score gains than non-program students from comparable schools in Oakland Unified. Moreover, those students also had higher CST-Math score gains than program students who received a lower dosage of chess instruction. For the lower dosage group, program impacts were not statistically significant. This is consistent with other studies that suggest that more chess instruction could facilitate the development of cognitive skills and capabilities (Hong, 2007). Bart (2004) suggested at least one whole academic year (around 40 weeks) as the duration for effective chess instruction. The finding suggests that higher dosages of chess instruction are more effective at raising student math achievement outcomes than lower dosages and should be taken into consideration when planning program implementation in Year 2 of the study.

We also found that for two subgroups, 3rd grade students and Special Education students, BCS program participation had a positive impact on school attendance, when compared to non-program students. This finding was consistent when we compared BCS program students to non-program students within the same school and to non-program students within the district. While previous studies have suggested that chess instruction could have a positive influence on Special Education students' concentration and calculation abilities (Scholz, 2008), there is no clear precedent that helps explain why chess would have a positive impact on student attendance among 3rd grade students. As such, this finding should be heeded with caution. Given the non-experimental design of this study, a possible explanation is that there is some sort of inherent bias in the 3rd grade sample that influences increased attendance among this subgroup of students in the program group. Alternatively, it is possible that chess resonates more with this age group and influences their overall engagement with school, which in turn could theoretically positively impact student attendance. However, measurement of such mediating factors would require the use of additional instruments.

¹ For this analysis, "academic achievement" refers to students' performance on the California Standardized Tests (CST) in Math and English Language Arts.

² Dosage data refers to the number of BCS instruction hours spent in each classroom, as reported by the Berkeley Chess School.

Finally, it is important to note the limitations with the design and scope of this study. As discussed, the results of the impact study are based on a non-experimental design that is subject to some threats to validity. While we have tried to mitigate these threats where possible, we cannot entirely rule out the possibility that some impacts are, to some extent, driven by self-selection biases in teachers and classrooms. In addition, because of small sample sizes and incomplete baseline year data, in some cases we did not have adequate statistical power to measure statistically significant effects. We hope that this problem will be lessened in Year 2 of the study, when we will have an additional year of test score data to work with.

What follows are a summary of findings from the BCS instructor focus group and classroom observations, and a more detailed discussion of the impact analyses and subsequent findings.

Instructors' Views on Goals of the BCS *First Moves* Program

The instructor focus group was conducted on May 1, 2009 with the goal of obtaining information regarding instructors' backgrounds, goals of the program, as well as to gain a better understanding of the fundamental components of the BCS *First Moves* program. BCS instructors were asked about their training, their views on what the goals of the BCS *First Moves* program are, what the program looks like in practice at OUSD classrooms, their perceptions of how students are responding to the instruction, as well as successes and challenges they have encountered. The contents of the focus group also informed the development of the semi-structured classroom observation guide.

As previously discussed, during the focus group, BCS instructors were asked what the goals of the BCS program are. According to one instructor, one fundamental and distinctive value that differentiates Berkeley Chess School from other programs is that their primary goal is not "to find the next Bobby Fischer." Rather, the goal is "to be able to take chess to all the kids, and to be able to get them to love chess as part of just being a renaissance person -- of life's experiences, and being able to take all the things that chess offers them that enrich the whole person."

Instructors also described a variety of values and life lessons students learned in chess such as motivation, staying focused, and self-efficacy, as benefits of chess:

"I think one of the things we can do for a kid is teach them how to learn, and teach them how to focus, and I think that's an extremely strong lesson in life... But I think that's one of the major lessons we can teach them, is that if you focus and you try, you can achieve."

"Well, one thing I hope they find is that things that are difficult are not scary. It's so easy to not bother because it's too hard, and I hope that they really figure out that things that are difficult just take patience, a little hard work and then the whole world opens up for you, and it translates to other things as well. Once you've done one really difficult thing in your life, the other difficult things aren't that scary anymore."

One instructor also added his views on the utility of chess as an educational tool:

"I think chess is a unique educational tool also in that compared to other sports where there's a team, in chess you're on your own. And the consequences of your actions are sometimes immediately apparent where they're not in a lot of other areas. So you have to accept responsibility, and—it's unique in a lot of ways, and, in that, it's also fun. It's a sport, yet they're also trying to concentrate as much as they can and learn."

Similarly, problem-solving and critical thinking skills are highly emphasized:

"This is your problem that you have to solve. How do you do it? Chess gives you that constantly."

“Personally, what I find most satisfying is when I find a student who is just not having a good time in school, a hard time with math, doesn’t feel like he’s good in anything, but when he starts playing chess, he just lights up, he’s one of the best players in the class and then he starts being good at the other things. It gives him that kind of confidence.

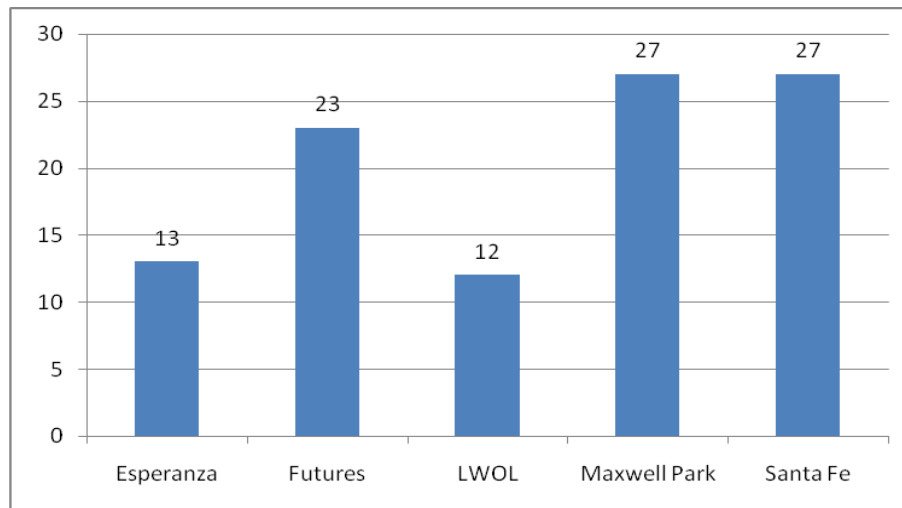
I’ve encountered so much of kids who are just - they are learning to copy things down in school, they’re not really learning critical thinking skills that are so necessary. And chess really helps you develop that, because as I like to say to the kids, ‘To be good at chess, you can’t just guess,’ you have to have a reason for why you do what you do, why you play the moves that you do, why you make the choices that you do, and there’s no one to copy off of, there’s no one to give you an answer. You have to [know what] the consequences are going to be -- you even touch a piece and you have to move it. So you have to think with your head before you even touch anything; otherwise, your opponent will use that against you. So there’s a lot that it teaches that I think the kids aren’t getting during the course of their week, just conceptual things.”

These views are consistent with the background literature that asserts that chess playing is a game that requires higher-order thinking skills (Hong & Bart, 2007), which in turn plays a major role in enabling students to better establish and attain goals, identify potential responses when making decisions, and achieve self-regulated learning (Wehmeyer, Palmer, Agran, Mithaug, & Martin, 2000).

Implementation of the Berkeley Chess School *First Moves* Program

The BCS *First Moves* chess instruction was implemented by 3 experienced chess instructors for one hour each week during the school day in 20 classrooms from five different elementary schools within the Oakland Unified School District. The level of implementation, with regard to hours of chess instruction, ranged from 11 weeks to 27 weeks. The variations in implementation were also taken into consideration in the impact analysis.

Figure 1: Average hours of BCS instruction during the 2008-09 school year



Implementation of the BCS curriculum was observed in three classrooms, two of which are part of the small schools movement³ in OUSD. Since 4 of the 5 schools in the sample are considered “small schools”, which supporters claim positively influence academic achievement and attendance (Shah & Mediratta, 2009), we conducted an additional within program comparison in the impact analyses to control for the small schools variable. The sample of classrooms to be observed was selected as a representative cross-section of all three grade levels (2nd, 3rd, and 4th) and all three instructors. Each classroom was observed using a semi-structured observation protocol developed by Berkeley Policy Associates and informed by the content of the in-person focus group with BCS instructors.

The goal of the classroom observations was to gain a better sense of the (1) overall classroom and school environment, (2) the content of the lessons in practice, (3) qualitative assessments of student engagement and behavior, and (4) instructor strategies. The classroom observations also help to provide a fuller picture of the contextual factors surrounding the implementation of the BCS curriculum in OUSD classrooms, and help identify the mediating factors that impact student achievement.

³ Also known as the Small Schools Initiative. A study by the Annenberg Institute for School Reform indicates that “small schools in Oakland are outperforming the large schools from which they emerged. In particular, students are completing more rigorous coursework and dropping out at lower rates, compared to the large schools.” (Shah, Mediratta, 2009).

In all three classrooms observed, chess instruction was provided in an interactive lecture style for approximately 20-30 minutes, leaving an additional 30-40 minutes for students to apply the lessons learned in their own games. Instruction in all three classrooms began with directing students to sit in front of the 2-dimensional demonstration [chess] board, followed by a review of the behavior rules and/or a particular concept (e.g. no hands on the tables and “kings don’t get gobbled”). These behavior rules were reinforced and repeated throughout the 1-hour of instruction, often reinforced by the classroom teacher when present. One classroom teacher especially emphasized the display of “chess tournament behavior” (operationalized during the class time as being quiet, raising your hand, and not speaking out of turn). Another behavioral concept observed in one class was that of tenacity and self-efficacy. One BCS instructor explained during the distribution of trophies from a class tournament that at one point, there was almost a 3-way tie in the tournament, but as a result of a student’s tenacity, the student was able to obtain a draw in the last game, which earned him the first place win by a half point.

In all three classrooms, the topic of checkmate was being discussed and practiced by students in different ways with varying forms of complexity. In one class that received approximately 9 weeks of instruction at the time of the observation, the students played in pairs using “2 armies” playing with just rooks and bishops, then again using only the queen and knights. Some students needed assistance in setting up their board, but appeared to be grasping the concepts, as evidenced by their ability to move each piece correctly and their application of checkmate during the play period.

In another class that received approximately 11 weeks of instruction at the time of the observation, a defensive move called “castling” which protects the king was introduced, in addition to the “4-move checkmate” and the “Rook Roller”. Throughout this lesson, the BCS instructor engaged the students by introducing a series of scenarios and asking students what the best move would be. Examples of the questions posed by the BCS instructor include: “Can you figure out how to capture the king with just 2 rooks? That wouldn’t work because the rook doesn’t move diagonally – what can you do instead? What is the first question you want to ask when you’re trapped?” These questions encouraged students to think critically and problem-solve within the context of the game.

In the third class, which had approximately 20+ weeks of instruction, students were preparing for a tournament. During this lesson, the BCS instructor emphasized that “copying moves would not yield a win” because “certain captures could not be copied, and more importantly, they would not learn to think critically.” This was used to segue into introducing various examples of “Discovered Check” scenarios where students were asked to identify the maneuver that would uncover the “Discovered Check.” As students weighed the costs and benefits of each move, the instructor facilitated their thinking regarding the number of points they would gain given the maneuvers they were weighing. Again, problem-solving and critical thinking were not only emphasized by BCS instructors, but also very clearly displayed through students’ verbal explanations of their rationale and thought process, and guided by the BCS instructor throughout the one hour instruction.

The classroom observations suggest that many of the values and skills that BCS instructors hoped to impart to their students during the chess instruction were in fact occurring. It is important to note, however, that while these observations certainly help to provide a fuller picture of the BCS *First Moves* Program in practice, and inform the interpretation of the impact analysis, the number and nature of the observations (semi-structured field notes as opposed to a structured instrument that, for example, uses a 5-point Likert scale that measures variables such as student self-efficacy and engagement that has been tested for its psychometric properties) cannot provide strong confirmation that those values were (a) being implemented across all program schools systematically; or (b) provide reliable confirmation of changes in students' ability to problem-solve, level of motivation, engagement, and feelings of self-efficacy with any statistical reliability or validity. Instead, these qualitative measures provide a framework for understanding how chess might help to improve student achievement. Given the framework provided by the observations and BCS instructors, the following impact analysis explores whether or not the values (e.g. tenacity, self-efficacy) and skills (critical-thinking and problem-solving) described during the focus group and observed during the classroom observations translate into improved academic achievement for OUSD students that participated in the BCS *First Moves* Program.

Impact Analysis

Data

The impact analysis is based on the comparison of program student test score gains on the California Standards Test (CST) with score gains of several non-participant comparison groups. The CST is a standards-based test administered annually to gauge the achievement of state content standards in English Language Arts (ELA), mathematics, science, and history-social sciences. The CST results were analyzed as scale scores, which range from 150 to 600. This analysis examines CST scores for Math and ELA only. Additionally, the analysis explores whether or not the BCS *First Moves* program had an impact on student attendance.

Methodology

In order to control for unobserved differences between the program and comparison groups, we employed a fixed effects methodology that analyzed year-to-year CST score gains as a function of student characteristics, program participation and an error term.⁴ The baseline years (2006-07 and 2007-08) revealed differences between the comparison groups before the program was implemented in the 2008-09 school year. Due to significant trends in the baseline years, the final models accounted for the previous years' scores. Differences in student characteristics between groups were also controlled for based on ethnicity, percent of English Language Learners, and percent of Special Education students. Only demographic factors which were significantly different between groups were included in the final models. First Differences regression models were used to assess the statistical differences between comparison groups, as well as control for the observed longitudinal trends and demographic differences between groups. A p-value of 0.05 was used to assess statistical significance.

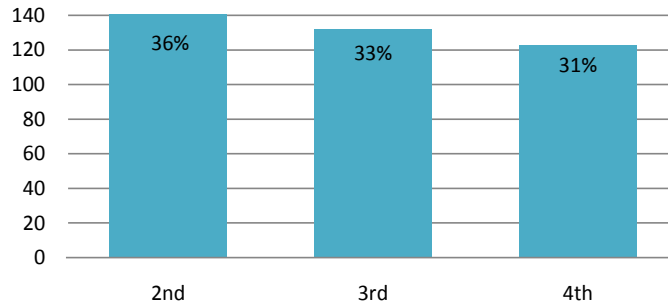
For the district comparisons, propensity score matching was used to find comparable schools in the district. We calculated propensity scores based on the following school characteristics: (1) percent of English Language Learners; (2) percent of Special Education students; and (3) ethnicity. We also restricted the pool of comparison group schools to Title 1 schools with more than 100 students in their 2nd, 3rd and 4th grade classrooms.

⁴ Because a comparison of student characteristics between the program and comparison groups during the baseline years (2005-06 and 2006-07) indicated that the program and comparison groups were non-equivalent groups, we decided to adopt a fixed effects (first-differences) approach that controlled for observable and unobserved differences between the two groups.

Description of Students in Program Group

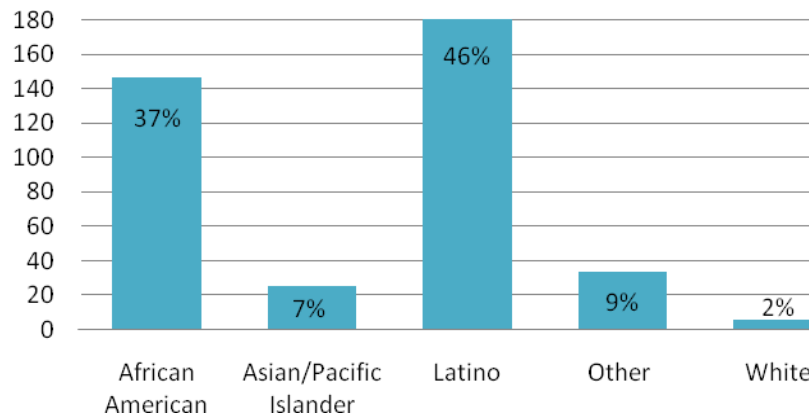
During Year 1 of the study, the Berkeley Chess School *First Moves* program provided chess instruction to 396 students in the Oakland Unified School District during the 2008-09 school year. The program group was divided almost evenly between 2nd, 3rd, and 4th graders (See Figure 1).

Figure 2: Grade distribution among the students in the *First Moves* Program 2008-2009



All schools in the program group receive Title 1 funding and serve primarily low-income, minority students. The majority of the students identified as either Latino (46%) or African American (37%). 54% of the students are or were at one point considered English Learners (includes Initial English Fluent and Reclassified English Fluent), and 8% of the students in the *First Moves* program were classified as Special Education students. With regard to gender, the program group is fairly evenly split and consists of 49% female students (n=192) and 51% male students (n=201).⁵

Figure 3: Ethnicity distribution among the students in the BCS *First Moves* Program 2008-2009



⁵ There were three students missing gender and ethnicity data.

Comparison Groups

In order to measure the impact of the BCS program on student outcomes, we compared program student outcomes with the outcomes of numerous comparison groups. With these analyses, we sought to answer the following research questions:

- 1) What impact did the BCS program have on academic performance and attendance compared to other students within the same school that did not receive the BCS chess instruction?
- 2) What impact did the BCS program have on academic performance and attendance compared to other students in comparable schools within the Oakland Unified School District?
- 3) How did BCS program impacts vary across groups defined by grade, gender, English Learner and special education status?
- 4) Does program dosage (measured by hours of instruction) positively impact student outcomes among program students?

Table 1: Comparison Groups Outlined

	BCS Program Group	Comparison Group
Within School Program Comparison		
1	All 2nd, 3rd, and 4th grade students in program classrooms	All 2nd, 3rd, and 4th grade students in comparison classrooms (within the same schools)
2	All 2nd graders in program classrooms	All 2nd graders in comparison classrooms (within the same schools)
3	All 3rd graders in program classrooms	All 3rd graders in comparison classrooms (within the same schools)
4	All 4th graders in program classrooms	All 4th graders in comparison classrooms (within the same schools)
District Comparison		
5	All 2nd, 3rd, and 4th grade students in program classrooms	All 2nd, 3rd, and 4th grade students in comparison classrooms (within the district)
6	All 2nd graders in program classrooms	All 2nd graders in comparison classrooms (within the district)
7	All 3rd graders in program classrooms	All 3rd graders in comparison classrooms (within the district)
8	All 4th graders in program classrooms	All 4th graders in comparison classrooms (within the district)
Subgroup Same School Comparisons		
9	All male students in the program classrooms	All male students in comparison classrooms (within the same school)
10	All female students in the program classrooms	All female students in comparison classrooms (within the same school)
11	All ELL students in the program classrooms	All ELL students in comparison classrooms

	BCS Program Group	Comparison Group
		(within the same school)
12	All Special Education students in the program classrooms	All Special Education students in comparison classrooms (within the same school)
13	All participants receiving a high dosage of chess instruction (more than 20 hours)	All 2nd, 3rd, and 4th grade students in comparison classrooms (within the same schools)
14	Program classrooms in OUSD small schools	All 2nd, 3rd, and 4th grade students in comparison classrooms (within the same schools)
Subgroup District Comparisons		
15	All male students in the program classrooms	All male students in comparison classrooms (within the district)
16	All female students in the program classrooms	All female students in comparison classrooms (within the district)
17	All ELL students in the program classrooms	All ELL students in comparison classrooms (within the district)
18	All Special Education students in the program classrooms	All Special Education students in comparison classrooms (within the district)
19	All participants receiving a high dosage of chess instruction (more than 20 hours)	All 2nd, 3rd, and 4th grade students in comparison classrooms (within the district)
20	Program classrooms in OUSD small schools	All 2nd, 3rd, and 4th grade students in comparison classrooms (within the district)
Within Program Comparison		
21	Program classrooms in OUSD small schools	Program classrooms in OUSD non-small schools
22	All ELL students in the program classrooms	All non-ELL students in the program classrooms
Dosage Analysis		
23	Low dosage (All 2nd, 3rd, and 4th grade students in program classrooms receiving less than 20 hours of instruction)	High dosage (All 2nd, 3rd, and 4th grade students in program classrooms receiving more than 20 hours of instruction)

Impact on CST-Math

A higher dosage of chess instruction is associated with a greater positive impact on student score gains on the mathematics section of the California Standardized Test. Those who received more than 20 hours of chess instruction, on average, achieved higher score gains (18.43 points) than those who received less than 20 hours of chess. Furthermore, those in the high dosage group of chess instruction, on average, had higher score gains (15.51 points) than 2nd, 3rd, and 4th grade students in within-district comparison schools.

The other comparisons revealed no statistical differences between groups after controlling for individual performance (accounting for previous year) and other demographic characteristics, where necessary. Besides those who received a high dosage of chess instruction, it is inconclusive whether or not the students receiving chess instruction performed any better or worse on the CST- Math than those who were not part of the program.

Taken together, these findings suggest that a more intensive program, with regard to number of hours spent on chess instruction, would more likely yield impacts detectable by the California Standards Test. Given the relatively low number of hours of chess instruction compared to what previous studies have suggested to see an impact, the lack of global impact on the CST-Math scores are expected and consistent with findings from other studies (Hong & Bart, 2007). Moreover, other studies (Horgan & Morgan, 1990) also suggest that there is a threshold effect associated with chess instruction: improvement in some higher order cognitive skills is achieved only after the student has attained a higher level of chess skill.

Additionally, other limitations of the analysis, such as having insufficient power, are discussed in more depth below.

Impact on CST-English Language Arts (ELA)

During the within program small school comparison (BCS *First Moves* classrooms in OUSD small schools compared to BCS *First Moves* classrooms in regular OUSD elementary schools), BCS *First Moves* students in the small schools were found to have higher scores on the English Language Arts section of the CST compared to the regular OUSD elementary schools also partaking in the *First Moves* program. However, since small schools are known to positively impact student achievement, additional analysis was conducted which compared BCS *First Moves* students in small schools against other students in small schools that did not receive chess instruction. The results yielded no significant gains in CST-ELA scores, which suggests that the gains in the first small school comparison are attributable to the small school environment rather than chess instruction. In summary, we found that program participation is not associated with score gains on the CST – ELA.

This finding is inconsistent with the Marguiles study (1991), which found that students in a New York City chess program significantly improved reading scores more than a control group at a 0.01 significance level. One explanation for this is that the sample in the Marguiles study excluded low-performing students (based on their performance on the Degree of Reading Power Test) and English Language Learners, which is markedly different from the population that the BCS *First Moves* program targets. Secondly, the amount and level of instruction provided was more intensive than the BCS *First Moves* program in that in addition to regular chess instruction, they enhanced their instruction with computer chess software. Finally, students in the Marguiles study self-selected into the chess program, which generally “attracts a higher percentage of excellent readers than are found in the general [district] population” (Marguiles, 1991).

Limitations of CST Analysis

There are some limitations with using the CST to measure gains in cognitive development for elementary school students. In general, standardized exams may be too blunt of an instrument to detect the gains in higher-order thinking skills associated with chess instruction. For example, The National Center for Fair & Open Testing states, “Standardized exams offer few opportunities to display the attributes of higher-order thinking, such as analysis, synthesis, evaluation, and creativity.”⁶ Critics also suggest that standardized tests measure superficial thinking and discourage the use of the results of a single test to make a policy decision (Kohn, 2000). Other studies (Hong & Bart, 2007) suggest using other instruments such as *The Raven’s Progressive Matrices Test*, which is designed to measure nonverbal abilities such as student perception of relationships in geometric figures and reasoning by analogy independent of language and formal schooling, or *The Test of Nonverbal Intelligence*, which is a norm-referenced test and a language-free measure of cognitive ability designed to measure problem solving, aptitude, and reasoning skills.

Another limitation is that the incomplete data and low subgroup sample sizes may have made it more difficult to detect statistically significant impacts for the study. We hope that this problem will be mitigated in Year 2, when we will obtain an extra year of student test score data.

This analysis also does not control for differences in teacher characteristics such as background education/certification, attitudes, and instructional practices, which influence student academic achievement (Palardy & Rumberger, 2008). Because teachers opt into participating into the BCS *First Moves* program, it is possible that the self-selection bias is driving some of the results and should be considered as another limitation of this analysis. The collection of teacher background data and attitudes towards chess instruction and their students could be important mediating factors that should be controlled for in future studies.

⁶ <http://www.fairtest.org/The+Limits+of+Standardized+Tests>

Impact on Student Attendance

Subgroup comparisons indicate that the BCS *First Moves* program participants attended school more days than they did in the 2006-07 school year compared to non-participants. Third graders in the program group missed significantly fewer days in 2007-08 than they did in the 2006-07 school year compared to third graders not in the program both within the school and in the comparable district schools. When compared against 3rd grade students within the same school but not partaking in the *First Moves* program, the 3rd graders in the program missed approximately 4 fewer days in the current school year than the prior year ($p=0.001$). Third graders in the program missed approximately 2 fewer days in the current school year from the prior year ($p=0.001$) compared to 3rd graders in the comparable district schools

Special Education students in the program also missed significantly fewer days in the 2007-08 than they did in the 2006-07 school year compared to special education students not in the program. When compared against Special Education students within the same school but not partaking in the *First Moves* program, the Special Education students in the program missed approximately 7 fewer days in the current school year than the prior year ($p=0.03$). Special Education students in the program missed approximately 6 fewer days in the current school year from than the prior year ($p=0.02$) compared to Special Education students in the comparable district schools

These findings suggest that the BCS *First Moves* chess instruction may have a positive impact on attendance among 3rd graders and Special Education students. However, in order to determine this more factually, a more in-depth analysis of the theoretical underpinnings that might support this finding should be conducted, in addition to data collection that can speak to the mediating factors such as, increased motivation or self-efficacy that may provide the link between chess instruction and increased school day attendance.

The other comparisons revealed no statistical differences between groups after controlling for individual attendance trends (accounting for previous year) and other demographic characteristics, where necessary. There is less of an issue with power for this outcome, because we have more complete cases for all grades. Considering this, the majority of absolute value of the group impact coefficients is less than 1, which suggests that there is little actual difference between most comparison groups, aside from the ones noted above.

Limitations of Attendance Analysis

We found no clear literature that helps explain the link between chess instruction and improved attendance. Given the non-experimental design of this study, a possible explanation is that there is an inherent bias in the 3rd grade and Special Education samples that influence increased attendance among this subgroup of students in the program group. Alternatively, it is possible that chess resonates more with this age group and influences their overall engagement with school, which in turn could theoretically positively impact student attendance. However, without additional data collection and further background research that more clearly solidifies the link between chess and attendance, this finding should be heeded with caution.

Conclusion

Returning to the first two research questions, which ask whether or not the BCS *First Moves* instruction had a positive impact on academic performance in the 2008-09 school year compared to other students within the same schools and compared to other schools in the district, the first year of data suggests that while there were not many statistically significant impacts, CST-Math scores did improve for students that participated in the BCS *First Moves* Program that received over 20 hours of instruction. As previously discussed, this finding is consistent with other research that suggests that a more rigorous chess program with regard to number of hours spent on instruction, as well as higher levels of chess skill attained, could lead to improved academic outcomes. Pogrow (1988) held that time and resources are key factors in developing higher reasoning skills, which implies that the Year 1 average of 17 hours of chess instruction implemented during the 2008-09 school year may have not been enough time for students to develop their chess skill and thus, improved cognitive development and academic achievement. Bart (2004) suggested at least one whole academic year (around 40 weeks) as the duration for effective chess instruction.

While CST-English Language Arts scores did not see a significant increase regardless of how much instruction was provided, this could also be because the cognitive translation from chess skills to word analysis, vocabulary, and reading comprehension may require more time to materialize in students' cognitive development and subsequent academic outcomes.

In response to the third research question which asks how BCS *First Moves* program impacts vary across subgroups, most of the data suggests that there are no significant gains in academic achievement among any of the subgroups. However, findings from the analysis of the attendance data suggest that chess instruction may have had a positive impact on attendance among 3rd graders and Special Education students. Finally, the fourth research question addresses the dosage effect, which, as previously discussed, was found to have a significant positive impact on the CST-Math scores among students with over 20 hours of participation in the BCS *First Moves* program.

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Appendix

Table A.1: Impact of Berkeley Chess School’s *First Moves* Program on Student Performance on the Mathematics Section of the California Standardized Test⁷

Comparison Group	Mean Difference		Impact Coefficient ⁸	Statistical significance	p-value	n
	P ⁹	C				
Within School Program Comparisons						
BCS students compared to students in same school: All (1)	19.2	27.7	-7.88	No	0.09	433
Among 3rd graders (3)	16.6	30.5	-9.71	No	0.11	221
Among 4th graders (4)	16.8	24.6	-7.56	No	0.29	206
District Comparisons						
BCS students compared to students in Title 1 schools in district (5)	19.2	12.7	6.48	No	0.14	675
Among 3rd graders (7)	16.6	6.7	9.99	No	0.10	333
Among 4th graders (8)	16.8	18.0	-1.22	No	0.85	336
Subgroup Same School Comparisons						
Female students from program group vs. other female students in comparison group (within the same school) (9)	22.2	27.1	-4.73	No	0.47	211
Male students from program group vs. other male students in comparison group (within the same school) (10)	16.4	28.2	-11.62	No	0.09	222
ELL students from program group vs. ELL students from comparison group (within the same school) (11)	18.6	20.5	-1.84	No	0.77	229
Special Education students from program group vs. Special Education students from comparison group (within the same school) (12)	22.1	53.1	-35.53	No	0.06	43
Only high dosage BCS students compared to students in same school: All (13)	26.2	27.7	-2.68	No	0.65	308
Program classrooms in OUSD small schools vs. non-program classrooms (within same school) (14)	19.9	29.1	-4.79	No	0.35	361
Subgroup District Comparisons						
Female students from program group vs. other female students in comparison group (within district) (15)	22.2	11.4	10.84	No	0.09	312
Male students from program group vs. other male students in comparison group (within district) (16)	16.4	13.8	2.57	No	0.67	363
ELL students from program group vs. ELL students from comparison group (within district) (17)	18.6	14.0	4.64	No	0.41	393
Special Education students from program group vs. Special Education students from comparison group (within district) (18)	22.1	21.6	1.82	No	0.90	60
Only high dosage BCS students compared to students in Title 1 schools in district (19)	26.2	12.7	15.51	Yes	0.01	550
Program classrooms in OUSD small schools vs. non-program classrooms (within district) (20)	19.9	20.7	-2.87	No	0.66	278
Within Program Comparisons						
	Yes	No				
Small school (21)	19.9	14.4	4.95	No	0.65	230
ELL students (22)	18.6	19.8	-13.48	No	0.38	230
Dosage Analysis						
High dosage (more than 20 hours of instruction) vs. low dosage (less than 20 hours) (23)	26.2	13.2	18.43	Yes	0.01	231

⁷ The numbers in parentheses in the column “Comparison Group” indicate the comparison group in Table 1.

⁸ The impact coefficient represents the isolated impact on the outcome after taking into account confounding factors.

⁹ P = Program group; C = Comparison group

Table A.2: Impact of Berkeley Chess School’s *First Moves* Program on Student Performance on the English and Language Arts Section of the California Standardized Test

Comparison Group	Mean Difference		Impact Coefficient	Statistical significance	p-value	n
	P	C				
Within School Program Comparisons						
BCS students compared to students in same school: All (1)	15.7	15.0	0.36	No	0.93	433
Among 3rd graders (3)	-6.5	-7.6	-1.23	No	0.79	222
Among 4th graders (4)	38.9	38.5	2.80	No	0.57	205
District Comparisons						
BCS students compared to students in Title 1 schools in district (5)	15.7	16.2	-0.50	No	0.89	675
Among 3rd graders (7)	-6.5	-5.5	-1.01	No	0.82	335
Among 4th graders (8)	38.9	36.7	2.15	No	0.62	337
Subgroup Same School Comparisons						
Female students from program group vs. other female students in comparison group (within the same school) (9)	19.5	12.15	6.82	No	0.23	212
Male students from program group vs. other male students in comparison group (within the same school) (10)	12.1	17.8	-5.77	No	0.32	221
ELL students from program group vs. ELL students from comparison group (within the same school) (11)	21.0	23.2	-2.21	No	0.68	230
Special Education students from program group vs. Special Education students from comparison group (within the same school) (12)	20.2	19.5	-1.97	No	0.90	42
Only high dosage BCS students compared to students in same school: All (13)	10.8	15.0	0.40	No	0.94	306
Program classrooms in OUSD small schools vs. non-program classrooms (within same school) (14)	18.3	-3.1	-1.80	No	0.68	361
Subgroup District Comparisons						
Female students from program group vs. other female students in comparison group (within district) (15)	19.5	16.9	2.60	No	0.61	315
Male students from program group vs. other male students in comparison group (within district) (16)	12.1	15.6	-3.46	No	0.47	363
ELL students from program group vs. ELL students from comparison group (within district) (17)	21.0	18.4	2.56	No	0.58	398
Special Education students from program group vs. Special Education students from comparison group (within district) (18)	20.2	12.1	7.41	No	0.58	61
Only high dosage BCS students compared to students in Title 1 schools in district (19)	10.8	16.2	-2.99	No	0.55	551
Program classrooms in OUSD small schools vs. non-program classrooms (within district) (20)	18.3	20.0	2.29	No	0.69	279
Within Program Comparisons						
	Yes	No				
Small school (21)	18.3	-2.3	20.53	Yes	0.03	231
ELL students (22)	21.0	9.3	4.66	No	0.70	231
Dosage Analysis						
High dosage (more than 20 hours of instruction) vs. low dosage (less than 20 hours) (23)	10.8	19.7	-4.21	No	0.51	232

Table A.3: Impact of Berkeley Chess School’s *First Moves* Program on Student Attendance

Comparison Group	Mean Difference		Impact Coefficient	Statistical significance	p-value	n
	P	C				
Within School Program Comparisons						
BCS students compared to students in same school: All (1)	-0.8	-0.3	-0.72	No	0.35	674
Among 2nd graders (2)	0.04	-2.4	2.26	No	0.15	226
Among 3rd graders (3)	-2.7	0.8	-4.11	Yes	0.001	235
Among 4th graders (4)	0.3	0.8	-0.55	No	0.65	213
District Comparisons						
BCS students compared to students in Title 1 schools in district (5)	-0.8	-0.8	-0.02	No	0.97	1060
Among 2nd graders (6)	0.04	-1.2	1.23	No	0.17	364
Among 3rd graders (7)	-2.7	-0.8	-1.81	Yes	0.03	347
Among 4th graders (8)	0.3	-0.4	0.68	No	0.41	349
Subgroup Same School Comparisons						
Female students from program group vs. other female students in comparison group (within the same school) (9)	-0.2	-0.3	-0.11	No	0.92	324
Male students from program group vs. other male students in comparison group (within the same school) (10)	-1.3	-0.3	-1.07	No	0.34	350
ELL students from program group vs. ELL students from comparison group (within the same school) (11)	-0.3	0.6	-0.96	No	0.18	342
Special Education students from program group vs. Special Education students from comparison group (within the same school) (12)	-4.8	0.6	-7.09	Yes	0.03	75
Only high dosage BCS students compared to students in same school: All	-0.9	-0.3	-0.14	No	0.89	478
Program classrooms in OUSD small schools vs. non-program classrooms (within same school) (14)	-0.7	-1.8	-1.14	No	0.16	541
Subgroup District Comparisons						
Female students from program group vs. other female students in comparison group (within district) (15)	-0.3	-1.1	0.83	No	0.25	495
Male students from program group vs. other male students in comparison group (within district) (16)	-0.5	-1.3	-0.78	No	0.24	565
ELL students from program group vs. ELL students from comparison group (within district) (17)	-0.3	-0.6	0.25	No	0.57	602
Special Education students from program group vs. Special Education students from comparison group (within district) (18)	-4.8	0.7	-5.60	Yes	0.02	101
Only high dosage BCS students compared to students in Title 1 schools in district (19)	-0.9	-0.8	0.09	No	0.89	864
Program classrooms in OUSD small schools vs. non-program classrooms (within district) (20)	-0.7	-1.6	0.91	No	0.34	413
Within Program Comparisons						
	Yes	No				
Small school (21)	-0.7	-1.3	0.12	No	0.94	352
ELL students (22)	-1.4	-0.3	0.76	No	0.69	352
Dosage Analysis						
High dosage (more than 20 hours of instruction) vs. low dosage (less than 20 hours) (23)	-0.9	-0.8	0.41	No	0.72	353