Chapter 1
The Problem and its Underlying Framework

This study examines the enactment of an elementary school mathematics teaching philosophy that was initiated with the intent to improve student mathematics achievement in a school district. The Cognitively Guided Instruction (CGI) elementary mathematics teaching philosophy has been shown to improve student achievement by improving instruction through enhancing teachers’ knowledge of students’ learning (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). Many researchers have demonstrated the strong positive link between student achievement and effective instruction (Sanders & Rivers, 1996; Nye, Konstantopoulos, & Hedges, 2004; Darling-Hammond, 2000; Haycock, 1998) as well as between effective instruction and high-quality professional development opportunities (Guskey, 1986, 2000; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). This study investigates the extent to which the principles of CGI are currently evident in classroom practice as well as the professional development activities that the observed teachers found to be the most effective in supporting their CGI practice.

Background of the Problem

A high-quality high school education can open doors for many students and pave the way to advanced degree attainment and higher earnings. However, not all high school courses equally influence later success. High school mathematics courses, in particular,
can have a powerful impact on students’ accomplishments after high school graduation (Adelman, 1999, 2006; Rose & Betts, 2001, 2004). A 1999 study by Adelman concluded that “finishing a course beyond the level of Algebra 2 more than doubles the odds that a student who enters postsecondary education will complete a bachelor’s degree” (p. 3). A follow-up study by Adelman (2006) concluded that “the highest level of mathematics reached in high school continues to be a key marker in pre-collegiate momentum, with the tipping point of momentum toward a bachelor’s degree now firmly above Algebra 2” (Adelman, 2006, p. xix). Adelman (2006) emphasized the importance of taking high-level mathematics classes, not only for the influence on higher education, but for its impact after graduation from college:

It’s not merely getting beyond Algebra 2 in high school any more: The world demands advanced quantitative literacy, and no matter what a student’s postsecondary field of study—from occupationally-oriented programs through traditional liberal arts—more than a ceremonial visit to college-level mathematics is called for. (Adelman, 2006, p. 108)

Rose and Betts (2001, 2004) studied links between high school mathematics coursework, the probability of graduating from college, and potential future earnings. The authors found that when controlling for occupation, demographics, and educational attainment factors, there existed a positive relationship between taking advanced mathematics courses, the probability of college graduation, and future earning power. “The math courses that students take in high school are strongly related to students’ earnings around 10 years later... algebra and geometry [are] systematically related to
higher earnings for graduates a decade after graduation” (Rose & Betts, 2004, p. 17). Rose and Betts (2001, 2004) additionally found that it is not only the number of math courses taken that matters, but the “extent to which students take the more demanding courses, such as algebra/geometry” (Rose & Betts, 2001, p. xx). High level mathematics courses, such as calculus, were found to have the largest effects while lower level courses had progressively smaller effects on graduation rates and future earnings (Rose & Betts, 2001).

Student success in high school mathematics courses is dependent upon a solid foundation of mathematical knowledge from elementary and middle school (National Mathematics Advisory Panel (NMAP), 2008). In preparation for Algebra, elementary mathematics curricula should “simultaneously develop conceptual understanding, computation fluency, and problem-solving skills” (NMAP, 2008, p. xix). Students cannot be expected to complete higher level mathematics courses without these prerequisite knowledge and skills; elementary and middle school mathematics courses must provide this groundwork.

In general, K-12 schools in the United States “are not doing a good job in preparing students, especially minority and disadvantaged students, to excel in school and to be successful in the labor market” (Rose & Betts, 2001, p. v). When compared both nationally and internationally, elementary and middle school students in the United States fared poorly in the basic mathematical skills necessary for success in high school mathematics courses (NMAP, 2008; Stigler & Hiebert, 1999). Without basic math skills,
student success in high school math is limited. The future of students across the United States is jeopardized when their achievement in mathematics is trivialized.

Student mathematics achievement, when compared nationally over time, has become stagnant. The National Assessment of Educational Progress (NAEP) studies educational trends within the United States using student achievement tests. The 2009 NAEP results described a trend of mathematics achievement within the United States that appeared to be leveling out; historically, student math achievement showed increased improvement each year but, in recent years, the increase in student math achievement has become steady and minimal (see Figure 1.1). Thirty states showed no significant change in mathematics test scores between 2007 and 2009 (National Center for Education Statistics (NCES), 2009a). This leveling out is not occurring at maximum student achievement levels; rather it is far below what has been determined to be proficient. When examining the figure below, note that, for fourth graders, a score of 249 is considered proficient and for eighth graders, a score of 299 is considered proficient.
NAEP has compared the fourth and eighth grade test scores of more than 160,000 students across the United States since 1990. Fourth grade student test scores in 2009 indicated that only 45% of students were scoring at levels that were proficient or above. While this proportion has increased since 1996, when testing accommodations were first permitted, there has only been a 9% increase in the percentage of students proficient or above in the last six years. Eighth grade proficiency scores showed perhaps a brighter picture. In 2009, 42% of eighth graders performed at proficient or above, significantly higher than in all previous years (NCES, 2009a). While this percentage is lower than that of fourth graders, there has been a greater increase over time. These proficiency levels

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**Figure 1.1. Fourth and Eighth Grade NAEP Mathematics Average**

*Significantly different (p < .05) from 2009.*

*Figure 1.1. NAEP mathematics scores for fourth and eighth graders from 1990 to 2009. For fourth graders, a score of 249 is considered proficient, for eighth graders, a score of 299 is considered proficient. Data from U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), various years, 1990 – 2009 Mathematics Assessments.*
remain troubling because, “what appears to matter most for increasing both earnings and the probability of graduating from college is that students progress beyond basic courses such as vocational math and pre-algebra toward more advanced topics” (Rose & Betts, 2001, p. 78); if students have low achievement levels in fourth and eighth grade they will most likely not have the necessary preparation for Algebra 2 in the following years.

NAEP additionally reports on the achievement levels in each of the individual 50 states. When examining student achievement in California, it is apparent that students are faring far more poorly than the national average. In the 2009 NAEP, while the percentage of California fourth graders scoring proficient or above did increase (by one percentage point) from 2007 to 2009, only 31% of students scored proficient or above; only three states/jurisdictions scored significantly lower than California’s students, the District of Columbia, Mississippi, and Alabama. California eighth graders’ performance is not significantly different. The percentage of eighth graders scoring proficient or above decreased (by one percentage point) from 2007 to 2009; 23% of California eighth grade students scored proficient or above (NCES, 2009b; NCES, 2009c). NAEP indicates that fourth and eighth graders in California are performing well below their peers nation-wide as seen in Figure 1.2.
Research has shown that effective instruction can be a powerful influence on student achievement (e.g., Gordon, Kane, & Staiger, 2006; NMAP, 2008; Nye, et al., 2004; Sanders & Rivers, 1996). In fact, teacher effectiveness has been found to have such...
a tremendous influence on student achievement that no student characteristic (such as race, poverty level, parent’s education level, etc.) has such an impact (Carey, 2004). The most effective teachers facilitate student achievement gains for students at all achievement levels (Sanders & Rivers, 1996) no matter their race or family circumstances: “In the hands of our best teachers, the effects of poverty and institutional racism melt away, allowing these students to soar to the same heights as young Americans from more advantaged homes” (Haycock, 1998, p. 11). Keeping this in mind, however, it is important to note that the National Mathematics Advisory Panel has declared that “the delivery system [instruction] in mathematics education – the system that translates mathematical knowledge into value and ability for the next generation – is broken and must be fixed” (NMAP, 2008, p. 11). As teacher instruction can have a powerful impact on student achievement and the instructional system in the United States has been declared to be “broken,” it is no wonder that students are not performing at high achievement levels.

The Third International Mathematics and Science Study (TIMSS) compared the math achievement of fourth and eighth grade students in 36 and 48 countries, respectively (Stigler & Hiebert, 1999). In addition to collecting student test score data, the TIMSS also collected data to compare instruction in classrooms internationally. The TIMSS recorded videotapes of instruction in eighth grade classrooms in the United States, Germany, and Japan. Upon analysis of these videotapes, American students were found to be “at a clear disadvantage in their opportunities to learn” (Stigler & Hiebert, 1999, p. 65). Instruction in the United States was characterized as “learning terms and practicing procedures”
because of the abundance of definitions presented to students and the vast amount of time students spent practicing skills (Stigler & Hiebert, 1999). When compared with their German and Japanese counterparts, U.S. students were found to be exposed to less challenging mathematics—mathematical content was, on average, at a mid-seventh grade level while the mathematical content in German and Japanese “lessons were at the high eighth- and beginning ninth-grade levels, respectively” (Stigler & Hiebert, 1999, p. 57). Mathematics classrooms in the U.S. tended to cover more topics less deeply than in other countries. Research (Stigler & Hiebert, 1999; NMAP, 2008) consistently demonstrates that math instruction in the United States includes less advanced topics presented in a more fragmented and prescriptive way when compared internationally.

Moreover, across the United States there exist substantial differences in teacher effectiveness (Nye, et al., 2004). These teacher differences are profoundly impacting the achievement of our students. While there is considerable variation in teacher effectiveness, there are ways to reduce that variation and improve the quality of instruction in order to improve student achievement. Through effective professional development opportunities, teachers can gain specialized content knowledge and learn to reflect on their practices in order to improve their classroom instruction (Loucks-Horsley, et al., 2010). Unfortunately, not all teachers are exposed to the same high-quality professional development programs (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). A promising strategy for improving student achievement may be in ensuring the effectiveness of teachers by providing high-quality professional development opportunities (Nye, et al., 2004). “Ultimately, the success of U.S. public
education depends upon the skills of the 3.1 million teachers managing classrooms in elementary and secondary schools around the country” (Gordon, et al., 2006, p. 5).

**Statement of the Problem**

It is clear from looking at performance data that student mathematics achievement in the United States is in need of improvement (NCES, 2009a; NMAP, 2008). A promising strategy to improve student achievement is to improve teacher effectiveness (NMAP, 2008; Nye, et al., 2004). The issue that follows is in determining how to inform the beliefs and actions of teachers in order to best improve teacher effectiveness.

Teachers often teach in the ways in which they were taught as students (Loughran, 2006; Stigler & Hiebert, 1999; Toll, Nierstheimer, Lenski, & Kolloff, 2004). These methods, such as “teaching as telling” and a focus on skills rather than concepts, are generally outdated and ineffective (Fuson, Kalchman, & Bransford, 2005; Loughran, 2006; Stigler & Hiebert, 1999). However, studies have shown that it is very difficult to change the ways that teachers teach (e.g. Guskey, 1986, 2000; Loucks-Horsley, et al., 2010; Loughran, 2006; Toll, et al., 2004). Recent research in teacher education has focused on how to best alter the beliefs and actions of teachers in both pre-service and in-service professional development programs in order to improve instruction and student achievement (Guskey, 1986; Loucks-Horsley, et al., 2010; Loughran, 2006).

Guskey (1986) investigated professional development in schools and he found that the majority of teachers participate in professional development because they want to
improve their teaching. Recent research by Webster-Wright (2009) additionally supports this finding. Unfortunately, professional development programs are often characterized by “disorder, conflict, and criticism” (Guskey, 1986, p. 5) and additionally occur in isolation from teachers’ classroom responsibilities (Darling-Hammond, et al., 2009; Guskey, 1986, 2000; Loucks-Horsley, et al., 2010). Many professional development programs fail because “they do not take into account two critical factors: what motivates teachers to engage in staff development, and the process by which change in teachers typically takes place” (Guskey, 1986, p. 6; Webster-Wright, 2009).

Effective professional development activities must provide teachers with practical, concrete ideas that can be used in the classroom immediately (Guskey, 1986; Loucks-Horsley, et al., 2010). Guskey (1986) provides three principles of effective development. The first is to recognize that change is a difficult and gradual process for teachers. Second, teachers must receive regular feedback on the learning progress of their students. Third, teachers must be provided with continued support throughout the year (Guskey, 1986). These principles are further supported by more recent research by Hammerness, Darling-Hammond, and Bransford (2005) and Loucks-Horsley, et al. (2010). It can be very difficult and resource-consuming to change the beliefs and actions of teachers. It is necessary, however, in order to improve student achievement in the United States.
Purpose of the Study

The purpose of this study is to examine one districts’ approach to addressing the quality of mathematics instruction in order to improve students’ academic achievement in math. Thus, this study focuses on teachers’ approaches to math instruction and student learning as they enact a philosophy of mathematics teaching. In addition, the study examines the districts’ support of teachers as they enact this philosophy.

Blue River Elementary School (BRES) was the first school in Green Valley Unified School District (GVUSD) to embrace the philosophy of Cognitively Guided Instruction (CGI), which focuses on cultivating specific teacher beliefs about learning, teaching, and applying effective instructional strategies in the classroom. Five years later, after BRES students experienced improvements in achievement on standardized mathematics tests, CGI was expanded to the other five district elementary schools. Green Valley Unified School District adopted CGI in order to improve student mathematics achievement across the district.

CGI has been accepted and used differently in each of the elementary schools; this study focuses on two specific elementary schools in the GVUSD. This study determines the degree to which the critical features of CGI are present in mathematics lessons as well as the teachers’ perceived impact of CGI professional development on their teaching practice. Because effective integration of the CGI philosophy necessitates that teachers’ beliefs and actions are aligned with those of CGI, the researcher investigated the current classroom practice of second grade teachers in an attempt
determine the alignment of the teachers’ actions to those of the critical features of CGI. Additionally, the researcher explored the aspects of CGI professional development that the teachers in this study perceived to have had the greatest impact on their CGI classroom practice.

Research Questions

1. To what extent do teachers’ instructional practices reflect the critical features of CGI?

2. What aspects of CGI professional development did the teachers perceive to be the most effective in supporting the integration of the CGI philosophy into their practice?

Importance of the Study

This study provides an investigation of the consistency of teachers’ instructional actions to those of CGI. Two specific elementary schools were examined where teachers in those schools were educated in the principles that guide CGI instruction. The degree to which the critical features of CGI were present in the classroom practice of these teachers was examined. Additionally, the CGI professional development that these teachers perceived to be the most effective in supporting their adoption and use of the CGI philosophy was explored. It is difficult to change the ways that teachers teach (Guskey,
1986, 2000; Loucks-Horsley, et al., 2010; Loughran, 2006; Toll, et al., 2004); the two schools in this study serve as examples of how difficult it is to align teacher actions to those of CGI.

**Methodology**

This study consisted of principal interviews and teacher observations, interviews, and questionnaires. The principal of each elementary school included in the study was interviewed in order to provide background information about the adoption of CGI at each school site. Teacher observations were conducted with second grade teachers at each of the schools to explore possible evidence of the critical features of CGI in their classroom practice. The interviews with the teacher participants served as a follow-up to the observations so that the impetus behind their actions could be explored. Questionnaires were distributed to each teacher who participated in the study to gather information about their past CGI professional development experiences as well as those experiences they found to be the most influential to developing their CGI practice.
Assumptions

For purposes of this study, it was assumed that principal and teacher responses in interviews and on the questionnaire were honest. Additionally, it was assumed that the observed lessons were typical examples of classroom practice for each teacher observed. This study attempted to determine the typical actions of teachers during “CGI lessons” in the two elementary schools where the study took place.

Limitations

Participation in this study was voluntary and relied on the willing participation and honesty of both the principals and teachers who were interviewed and completed questionnaires. When teachers were observed in their classrooms, it was important that they did not alter their practice for our observation; the goal was to see a typical mathematics lesson so that our observation was a true example of that teacher’s instruction. It is not possible to know how consistent the lessons that were observed for this study were with each teacher’s typical classroom practice. Since only two observations took place in each classroom and the teachers knew that their CGI practice was being studied, it was impossible to gain a complete view of each teacher’s typical classroom practice (Patton, 2002).

Additionally, the researchers did not observe the professional development that the teachers in this study were provided, nor did the researchers investigate how CGI had
evolved at each school. This study simply considered what CGI looked like in second
grade classrooms in the two schools at a moment in time; the reasoning behind why the
classrooms looked the way they did is beyond the scope of this study.

**Delimitations**

This study was limited by the amount of time and man power available to complete classroom observations and teacher interviews. Because there were only two researchers collecting data for this study, the number of classrooms that were observed, as well as the number of observations, were fewer than would have been ideal; each teacher was observed two times during “CGI mathematics lessons.” The researchers were not able to observe the teachers as they taught other subjects or taught “non-CGI” lessons. As CGI is a philosophy, its principles may have been evident in the general teaching practice of the observed teachers; unfortunately, that is impossible to determine in this study.

Second grade teachers were observed at the recommendation of one of the school principals and the teachers were voluntary participants; the sample was not chosen randomly nor was it based on specific criteria determined by the researchers, thus the ability to generalize the findings to other grade levels within and across schools in the same district may be limited (Patton, 2002). Further, this study is limited to two schools within one school district and thus may not be representative of all schools and districts that use or have used the principles of CGI.
Definition of Terms

1. API: Academic Performance Index. In California, the API was established by law in 1999 in an attempt to create an academic accountability system for K-12 public schools. The API is calculated using students’ performance scores on state assessments in multiple content areas. The API for a school can range from a low of 200 to a high of 1000 (California Department of Education (CDE), 2010).

2. CGI: Cognitively Guided Instruction. This is an elementary school mathematics philosophy that focuses on the instructional decisions that teachers make in the classroom based on the knowledge and beliefs that teachers have of their students (Fennema, Carpenter, & Franke, 1992). Chapter 2 provides a more complete description of CGI.

3. CGI Implementation: While CGI is a philosophy of teaching elementary mathematics, the district and schools that participated in this study referred to it as if it were a program that was used at specific times. For example, the teachers taught “CGI lessons” twice per week where they claimed to use the CGI philosophy in their teaching, “non-CGI lessons” during the rest of the week when they used different curricula, and continually referred to their “CGI implementation.” While CGI is a system of beliefs meant to be integrated into mathematics teaching practice (Carpenter, Fennema, Franke, Levi, & Empson, 1999), the teachers and
administrators in the schools often spoke of CGI as if it was separate from general mathematics instruction. It is unclear if the language by which they refer to CGI was self-created or if it was part of the professional development they received. The researcher will use the term “CGI Implementation” in chapters 4 and 5 because that is the way that CGI is referred to in the schools; she is aware that this vocabulary is most likely not intended to be used to describe the adoption of the CGI philosophy by the developers of CGI.

4. NAEP: National Assessment of Educational Progress. NAEP is conducted by the U.S. Department of Education and provides national results of student achievement, instructional practices, and the school environment. The results are based on samples of students in 4th, 8th, and 12th grades and provide a common measurement for all states. NAEP is administered periodically in mathematics, reading, science, writing, the arts, civics, economics, geography, and U.S. history (NCES, 2010).

5. NMAP: National Mathematics Advisory Panel. In 2006, the President of the United States created NMAP to advise national educational decisions with the goal “to foster greater knowledge of and improved performance in mathematics among American students … with respect to the conduct, evaluation, and effective use of the results of research relating to proven-effective and evidence-based mathematics instruction” (NMAP, 2008, p. 7). The Panel compiled the findings that resulted from 20 months of

6. Professional Development: Professional development is “a systematic attempt to bring about change–change in the classroom practices of teachers, change in their beliefs and attitudes, and change in the learning outcomes of students” (Guskey, 1986, p. 5). Professional development can take many forms, such as workshops, conferences, learning communities, coaching, and college courses (Desimone, 2009).

7. TIMSS: Trends in International Mathematics and Science Study.

Compared the mathematics and science achievement of students in 41 nations and collected observation videos from eighth grade classrooms in German, Japan, and the United States (Stigler & Hiebert, 1999).