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# Cognitively guided instruction (CGI) for mathematics at the elementary school level

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# Senior Capstone Binder

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### By

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**Cognitively Guided Instruction (CGI) for Mathematics at the
Elementary School Level**

**Introduction and Background**

In my search for a topic, I attended the 1st Annual Capstone Opportunities Fair at California State University Monterey Bay (CSUMB). One of the representatives I spent time with worked at a local high school. She commented that many of the incoming students did not have a good, solid foundation in mathematics that adequately prepared them for high-school level work.

This sparked my curiosity. The amount of mathematical knowledge students manage to retain from their elementary school years clearly plays a key role in determining how they will fare in high school. Was this a widespread rather than an isolated problem that the representative had described? If so, why? Has this been a long-standing difficulty? Have teachers altered their approach to teaching math in recent years? As a future teacher, I have a vested interest in discovering the answers to the previous questions.

Clearly there is a need for change. As author Gloria Ladson-Billings reports, "Most of the research that has investigated the state of elementary mathematics in the U.S. indicates that our elementary mathematics curriculum is filled with rote learning of low level arithmetic" ("Dangerous Pedagogy" 5). To correct this problem, children need to be taught in such a way that their understanding of mathematical concepts is just as important as the computations they perform. When I explored the area of math pedagogy, a study that seemed to be at the forefront of research on improving teaching techniques in

this area eventually caught my attention; the concept was dubbed "Cognitively Guided Instruction," and it is targeted for the Kindergarten through third grades.

My concentration is mathematics, so this paper will fulfill both Major Learning Outcome (MLO) C10 (Depth of Study/Emphasis) and MLO C5 (Quantitative Literacy). In addition, I plan to investigate whether or not the tenets of CGI are compatible with certain cultures. This will complete MLO B1 (Cross-Cultural Competence).

The primary research question I propose to answer in my paper is: What does research say about teaching math to elementary school children through the utilization of CGI techniques? Secondary research questions include the following:

a)  What is CGI, and what were the circumstances surrounding its origin and development?

b)  How does CGI differ from traditional math instruction?

c)  How does CGI change the way elementary school teachers teach math?

d)  How effective is CGI?

e)  Are there additional benefits that stem from the implementation of CGI in elementary school level classrooms?

f)  Are there sufficient resources available for elementary school teachers should they decide to implement CGI in their classrooms?

**Literature Review**

In order to answer the aforementioned research questions, an assortment of books and online publications, including newsletters and a research report, were assembled and consulted. In light of the fact that absolutely nothing was known about this topic beforehand, the vast majority of the sources accumulated were informative in nature, and nothing that put CGI in a negative light was sought aside from the traditional math approach which, of course, gave rise to CGI in the first place. The rationale behind this decision was the belief that a basic understanding of a new concept must be solidified before any criticism can be meaningful.

Although CGI is a relatively new concept introduced in the early 1990s, I had little trouble securing both online materials and several texts of immense assistance to my research at CSUMB's library. Concerning the former, a research report by several of the original founding members of the movement and several of their articles compiled in *The Newsletter of the Comprehensive Center – Region VI* were extremely valuable, as was the Comprehensive Center-Region VI's website itself, dubbed "The CGI Spider." This particular spider did indeed spin a web of exceedingly useful resources.

According to the Mission and Description page on their website at the University of Wisconsin-Madison, "the Comprehensive Center-Region VI (CC-VI) is part of a federally-funded network of [15] technical assistance centers that supports and assists states, districts, and schools meet the needs of children served under the Improving America's Schools Act (IASA), which reauthorized programs under the Elementary and Secondary Education Act (ESEA) of 1965" (Mission and Description).

The books *How to Teach Mathematics* and *Insights into Teaching Mathematics* by Steven G. Krantz and the duo of Anthony Orton and Leonard Frobisher respectively were helpful in supplying background information about the movement towards teaching with more emphasis on comprehension as opposed to algorithm replication. Another, entitled *Teaching Mathematics through Problem Solving: Prekindergarten – Grade 6*, was edited by Frank K. Lester Jr. and Randall I. Charles, and it also provided convincing arguments for this movement. Elizabeth Fennema is one of the original researchers from the University of Wisconsin-Madison whose labors partially founded the CGI movement, and as such her works constitute an authoritative source on the topic. A copy of the book titled *Mathematics Teachers in Transition*, which she co-authored with Barbara Scott Nelson, was secured from the library at CSUMB.

An excellent source supplied by my capstone advisor was *Native American Pedagogy and Cognitive-Based Mathematics Instruction*, a dissertation by Judith Elaine Hankes. Her work, which was supervised by Elizabeth Fennema, investigated "the influence of CGI on the mathematical problem solving skills of Oneida Indian kindergarten children" (xxiii). As such, it provided an example of the cultural compatibility of CGI, and another example authored by William H. Schmidt and fourteen others was supplied by the book titled *Characterizing Pedagogical Flow: An Investigation of Mathematics and Science Teaching in Six Countries*.

To reiterate the explanation for the absence of viewpoints opposing the implementation of CGI, save for the traditional math approach, the decision was made that, rather than including elements characteristic of a persuasive paper, this would constitute a purely informational document. In the end, this choice was justified, for the

length of this document is already considerable; including persuasive components would

have enlarged it substantially.

## Research Method(s) and Procedures

In the beginning of the research-collection phase of my capstone, I primarily utilized the Voyager search engine at the CSUMB library. In this manner I found several excellent books and mistakenly concluded that these would constitute the cornerstone of my cited material. However, I continued to browse the Internet and eventually stumbled on a website dubbed "the CGI Spider," the official website of the aforementioned Comprehensive Center-Region VI. This proved to be a veritable gold mine of online sources including research reports, newsletters, and a host of other articles relating to CGI. Overall, a great deal of time was expended reading, synthesizing, and attempting to comprehend the information found in the various sources gathered.

## Results and Discussion

### *What is CGI, and what were the circumstances surrounding its origin and development?*

When discussing a new concept, it is of paramount importance that terms, definitions, acronyms, and unique vocabulary in general be discussed to prevent confusion. Although the acronym CGI was explained in the title, defining the term itself is slightly more complex. It can best be summarized by those who conceived it, Thomas P. Carpenter, Elizabeth Fennema, Megan Loef Franke, Linda Levi, and Susan B. Empson, who give the following definition: Cognitively Guided Instruction is a professional development program based on an integrated program of research focused on[:]

a) the development of students' mathematical thinking;

b) instruction that influences that development;

c) teachers [sic] knowledge and beliefs that influence their instructional practices; and

d) the way that teachers' knowledge, beliefs, and practices are influenced by their understanding of students' mathematical thinking (1).

To paraphrase, this method involves educating teachers on the fine points of how children think and how they learn mathematics, and this information is combined with an understanding of what influences their own teaching practices; the training is accomplished through a week-long workshop program. The teachers then integrate this knowledge with pedagogy consistent with what they have learned and proceed to implement it in their classrooms.

A brief recap of the origins of CGI will now be discussed. Initially, Cognitively Guided Instruction was intended to be a project lasting three years during which the researchers would educate teachers on how children learned and thought about mathematics; the researchers would then proceed to study "the *impact on learning* of the children in these teachers' classrooms"; Professor Fennema placed special emphasis on the application of the research because the vast majority of research conducted prior to that point never found its way into classrooms and thus had little practical value to teachers in the field (Foster 4). In the beginning, the researchers also wanted to instruct the teachers on how to use their newfound knowledge, but eventually that notion was scrapped. Professor Fennema later related that this "turned out to be the best decision we ever made…Teachers have so much knowledge about the practicalities of teaching and about children that they were much better able to implement something than if we had told them what to do" (Foster 4).

She and her fellow colleagues, afraid that their presence would have unfortunate consequences by affecting the end results in some way, assiduously avoided the classrooms until their curiosity finally got the best of them when the study had almost been completed. They were absolutely astounded at the incredible impact on children's learning that their work had started (Foster 4). The CGI movement was off and running.

One principle heavily emphasized by the CGI founders in numerous sources is the central role played by children's thinking about mathematics. According to the research report generated by Carpenter et al., "The theme that tied together our analysis of students' mathematical thinking is that children intuitively solve word problems by modeling the action and relations described in them" (2). The initial research report also

showed that while most of the teachers were entering the workshop program with a decent understanding of their students in this respect, it was basically dormant knowledge; its use in day-to-day mathematical activities was exceedingly minimal. The workshops are designed to reinforce and expand the teachers' grasp of this type of information and how to put it to practical use (Carpenter et al. 2).

### *How does CGI differ from traditional math instruction?*

"Traditional" math instruction was the most prevalent form of instruction during my elementary school years. By "traditional," I mean that the typical lesson involved the teacher introducing the new concept for the day, using the algorithm we were expected to learn to demonstrate a problem, and fielding questions before finally turning us loose to replicate the algorithm on our own. Almost all questions asked had to do with a step in the algorithm. Those who managed to come up with the correct answer were assumed to have understood the concept.

Unfortunately, this assumption is not always true. As authors Anthony Orton and Leonard Frobisher assert, "Pupils whom teachers regard as being particularly intelligent usually have swift and reliable retrieval systems, in that they recall things quickly and accurately…it seems likely that a good memory is only a part of what is involved in understanding" (13). In the eyes of some students, mathematics has consequently earned a negative reputation in that it is perceived as a mindless set of procedures to be performed by rote.

This drawback is a dilemma faced by traditionalists who "want to continue giving lectures, want the students to do traditional exercises…and want to continue to drill their

students"; in contrast, the viewpoint of reform movement proponents argues for

"discovery, cooperative and group learning…and …downplays rote learning and drill"

(Krantz xi). To summarize the previous statements, the traditionalists' approach places

priority on the students knowing *how* to solve problems with the hope that s/he will

understand *why* later on, if not during a brief teacher introduction to the topic. For the

reformers, these priorities are reversed, and understanding is a critical component

throughout the entire learning process; algorithm duplication takes on secondary

importance.

        Authors Frank K. Lester Jr. and Randall I. Charles posit, "The primary goals of

mathematics learning are understanding and problem solving…these goals are

inextricable related because learning mathematics with understanding is best supported

by engaging in problem solving" (6). They further state that these two share a mutually

beneficial link: "Understanding enhances problem solving…Learning through problem

solving develops understanding" (Lester and Charles 7). When compared to traditional

math instruction, CGI lands squarely in the camp of the reformers, a revolutionary

method that places great emphasis on imparting understanding to each student.

### *How does CGI change the way elementary school teachers teach math?*

        One unique aspect of CGI is the fact that, as stated by Judith Hankes, "it does not

prescribe instruction or provide instructional materials…the goal is that teachers will be

able to understand how their children learn mathematics concepts and that this knowledge

will inform instruction" (26). Because CGI goes against the grain of traditional math

pedagogy, the practical application of the techniques demonstrated in the workshops is

where the rubber meets the road, for the teachers are expected to slowly implement sweeping changes in their approach toward teaching mathematics. Teacher change can involve three main factors: beliefs, knowledge, and practice (Fennema and Nelson 255). The inventors of CGI have developed a rating system consisting of Levels 1 – 4, with the 4th level further divided into two sublevels, 4A and 4B, designed to track and categorize the progress teachers make in their implementation of the new concept.

Traditional teachers fulfill the criteria for Level 1. Their teaching often revolves solely around a textbook holding a monopoly as far as methods are concerned; alternatives are rarely, if ever, discussed. In addition, the teacher holds the attitude that the students must be shown step by step what to do. The idea that they could solve problems independent of the teacher's direct instruction is not even considered (Carpenter et al. 4).

At Level 2, the iron grip the textbook holds begins to loosen, and the teacher allows and may even solicit the discussion of other ways to solve problems. The key at this level is the fact that "teachers begin to believe that children can solve problems without being explicitly taught a strategy" (Fennema and Nelson 266). However, the book's way is never completely forsaken, and the discussions appear sporadically with no real purpose behind them save for the mere action of putting other strategies on the table (Fennema and Nelson 266-267).

Level 3 is certainly, as the research report by Carpenter et al. states, "a turning point. Level 3 teachers believe that children can solve problems without having a strategy provided for them, and they act accordingly. They do not present procedures for children to imitate" (4). Like Level 2, the key to Level 3 is related to the teacher's attitude towards

his/her students' capabilities. In this case, however, the attitude is the polar opposite of that described in Level 2, for it is now the lively teacher-to-student and student-to-student discussions that take center-stage while the textbook languishes on the back burner. This dialogue captures the spirit of CGI, where children engage each other as well as the teacher in stimulating deliberations debating the pros and cons of various strategies that they or their peers have come up with. In this way, the students are making connections between the new material and their mathematical foundation on their own, which makes the learning process much more meaningful than if the teacher had merely told them what to do.

While the main objective has been achieved at Level 3, teachers can take it to another level – literally. The difference between Levels 3 and 4 has to do not only with the teacher's ability to stimulate and sustain the class discussion, but also how s/he ultimately uses it. Based on the sources consulted, I believe that the critical difference lies in how deeply the teacher can take the class in their explorations of the strategies presented. Some teachers are more adept than others at not only bringing out the best in their students, but also challenging them to take things one step further.

The dividing line between Levels 4A and 4B is rather subtle. According to authors Elizabeth Fennema and Barbara Nelson, while teachers at Level 4 in general "believe that what they learn about their children's mathematical thinking should help them make instructional decisions," Level 4A teachers do "not necessarily or consistently base practice on knowledge of children's thinking" (268).

Level 4B teachers, however, have reached the pinnacle, and they distinguish themselves by placing emphasis on each individual student. Clearly, this is not the main

approach taken towards instruction aimed at the entire class; rather, it denotes a continuously growing body of specific knowledge about each of their students that enables them to quickly switch to a problem tailored to a particular child's needs and back again (Fennema and Nelson 269). The researchers noted that "for teachers to move beyond Level 3 in classroom practice, belief changes are essential" because "at this level, particular practices cannot be prescribed or explicitly modeled; making decisions about classroom practice depends on a strong epistemological base" (Fennema and Nelson 271 – 272).

### *How effective is CGI?*

When a new teaching strategy is introduced, a natural question that arises deals with its effectiveness. Numerous studies have shown that CGI is indeed an effective mathematical teaching technique, and the results are remarkable if given sufficient time to develop. Professor Fennema cautions that "change 'doesn't take place in a week, or a month or a year…the *most* growth will take place over a period of several years'" (Foster 7). However, the results are well worth the wait. Jonathan L. Brendefur and Sherian E. Foster had this to report from "five teachers…interviewed at the 2000 Advanced CGI Workshop. All were emphatic in saying that, by focusing on understanding student thinking, they were astounded at what their students knew and could do" (16).

Of course, the teachers are not the only ones who are being amazed. The following is an account given by an African-American mother whose 8-year-old 3rd grade daughter was being taught with CGI techniques:

Sometime near the end of the first semester, I saw a renewed confidence in my

daughter. She was whizzing through math problems. One day she asked me a

rather mundane question like, "how [sic] much is 54 minus 17?" I quickly jotted

down the numbers on a piece of scrap paper and my 8-year-old said, "You mean

you need a piece of paper to answer that question? Can't you tell that 54 is almost

55 and 17 is almost 20? Fifty-five minus 20 is 35. You added one to the 54 and

you added 3 to the 17. Subtract one from three and add it to your 35. Now you've

got 37." I stared at my daughter with astonishment. She had a strategy! She had

command of a mathematical problem without a routine algorithm. I realized that

she had benefited from CGI…she had knowledge she could use. ("Experience"

11)

This was her daughter's first year in a class taught using CGI, and clearly progress was

already being made.

The CGI Spider website reported the following brief summary about the effective

of CGI:

Pre- and post-test results revealed that first-year CGI students outscored

comparison students on a battery of arithmetic problems. For first graders, the

difference in favor of the CGI students was 0.33 standard deviation; for second

graders, it was 0.47 standard deviation. For third graders, the difference reached

an astounding 0.66 standard deviation (by way of comparison, a standard

deviation on the SAT is equivalent to 100 points).

Title I, bilingual, and American Indian students in CGI classrooms outperformed

their peers. Also, CGI teachers reported teaching much more difficult

mathematics content and felt a greater sense of effectiveness than did their non-

CGI colleagues.

Walter G. Secada and Jonathan L. Brandefur note that "one half of one standard deviation

is considered large," and they also report that in one study involving first graders, CGI

students posted higher scores than their non-CGI peers by a minimum of 3 to a maximum

of 6.63 standard deviations (Secada and Brendefur)! Carpenter et al. also claim that in

spite of the decreased emphasis on computational skills, CGI students fared no worse

than non-CGI s students in this area (6).

The CGI Spider also listed seven school sites with a significant number of

teachers utilizing CGI; it included a link with information specific to each school and a

set of tables showing a comparison of the test results of CGI and non-CGI students.

Despite the fact that five of these school links were under construction at the time of my

research, the remaining two showed CGI students achieving scores far superior to their

peers who were not learning under the guidance of the new technique. For complete

results please refer to Appendices A and B. In addition, Appendix C is composed of an

excerpt from the article "CGI Student Achievement in Region VI Evaluation Findings"

with further information showing positive CGI student results.

***Are there additional benefits that stem from the implementation of CGI in elementary
school level classrooms?***

To add to its appeal, CGI also has several side-benefits and applications. One of these is the impact on students labeled "at-risk" in their reading capabilities and those whose primary language is not English, as evidenced by the following passage:

> Although all teachers reported using CGI tenets and principles in other subject areas, the teachers of Reading Recovery and of English Language Learners (ELL) were most emphatic on this point. A third-grade teacher said that using CGI "really demands that children work together and do a lot of dialoging and sharing…It's really rich in language usage. If you use CGI, children are listening speaking, reading, and – another important aspect – *writing* their own problems." One teacher said, "I adapted CGI problems directly to my reading and phonics program." (Brendefur and Foster 17)

In addition, CGI is more compatible for culturally diverse classrooms than traditional mathematics instruction. Granted, both attempt to elicit direct responses from students, but CGI typically places more emphasis on aspects many cultures find acceptable. Judith Hankes provides a glimpse of the research material presented at workshops that is pertinent to this topic; a critical cornerstone of CGI is summarized in the following quote concerning children solving problems:

> Children from other culture groups: Hispanic children…African American children…and Lebanese children…demonstrated the same regularities in their solutions; apparently, learners across cultures share similar cognitive processes when intuitively solving mathematical story problems (27).

This quote about the foundation of CGI being based on an aspect of children's thinking that transcends cultural barriers is a significant one, because she based her dissertation on

the compatibility of CGI and general Native American pedagogy. She further posits,

"The extensively documented mathematics underachievement of Indian students is partly

caused by cultural conflict: conflict between the values and beliefs of the dominant

culture and Native American culture" (xii).

A few guidelines prevalent in Native American classrooms are the following:

a.      Teacher as facilitator – indirect rather than direct instruction

b.      Problem-solving based on sense-making – each student is allowed to solve

problems any way that makes sense to that student

c.      Cooperative rather than competitive instruction (Hankes 26)

CGI fulfills all three of these criteria. The teacher, rather than explicitly showing the class

what to do on a particular problem, attempts to extrapolate this information from each

student. Not all of the proposed strategies to reach the correct solution will be identical,

and this is perfectly fine. A child's original method is more meaningful to him/her than

one imposed externally. Thus, points a. and b. are covered. Finally, the class discussions

promote group learning, as students show each other what, why, and how they did what

they did. This is critical to cooperative instruction, which fulfills point c.

Although the points were listed in a dissertation focusing exclusively on Native

Americans, they are also applicable to other cultures, notably several Asian countries.

Researchers William H. Schmidt et al. report the following about a classroom practice in

Japan:

'Hans,' small groups of students commonly formed for discussion and activity

purposes during lessons, were often used to further work on a problem after which

each 'han' was asked to present its results to the whole class…After reports by

each han, the whole class discussed the various solutions provided and eventually

ended with the best solution for their purposes. (93-94)

This is one example of several cultures compatible with CGI techniques. Basing the

approach on a principle that transcends cultural lines gives CGI a solid foundation.

***Are there sufficient resources available for elementary school teachers should they
decide to implement CGI in their classrooms?***

The first step for those who decide to implement CGI in their classrooms is

gaining administrator/principal approval to attend a CGI workshop. The Comprehensive

Center-Region VI (CC-VI), the organization that hosts these events, prefers that schools

send not only a minimum of two or three teachers, but also "one specialist (the

mathematics coordinator, Title 1 coordinator, or principal, for example). This encourages

ongoing, broad-based support once teachers are back in their schools implementing CGI"

("Cognitively" 14).  One interesting requirement "asks each team to submit a letter from

their principal pledging to support the teachers' use of CGI in their classrooms. Without

outright principal consent any reformed, [sic] practice can easily be thwarted"

("Cognitively" 14). The CGI Spider, which is maintained by CC-VI, is the website of

choice for information concerning the dates, times, locations, and even the workshop

leaders of both past and upcoming CGI workshops and conferences.

In addition, the CGI Spider is an excellent source of support. Included in its vast

cache of webpages are the following:

a)  Newsletters and research articles about CGI

b)  Stories from past CGI participants

c) Articles about elementary schools currently implementing CGI

d) A web board and chat room for ongoing and real-time conversation about CGI ("Cognitively" 14)

Links are provided for all of the bulleted items listed above as well as other related topics of interest. CC-VI responds to phone calls and e-mails, and even sends out specialists to fulfill requests by school sites in need of assistance ("Cognitively" 14). Thus, a wealth of support is available for those who decide to pursue CGI.

**Research Problems or Limitations**

As mentioned in the section titled "Research Method(s) and Procedures," I came across the CGI Spider website after going through several books checked out at CSUMB's library. However, this discovery was made late enough in the semester that I was unable to fully explore it to my satisfaction, and as a result this lends, in my mind at least, a minor feeling of incompleteness to the entire capstone work. To further complicate matters, these online sources contained a wealth of statistical data documenting the superior performance of students in CGI classrooms as opposed to that of their peers in non-CGI classrooms. An insufficient interval of time remained for me to conduct a thorough exploration of the meaning and implication of the data and forced me to merely include pieces of this information in Appendices A – C. I therefore cite time as my primary research limitation.

Had time permitted, I would also have liked to interview one or more teachers who had completed the CGI workshop and implemented CGI instructional techniques in their classrooms. Querying them on the changes they had witnessed due to the new approach, the advantages and drawbacks, the presence or absence of a noticeable impact on state-level standardized tests, and related topics would have been extremely valuable to this paper.

Finally, I would have liked to observe this method of instruction being implemented in a classroom setting for one or more designated math periods. Although there were plenty of individual story problems and case studies, I increasingly felt like I was dealing with something too abstract for me to receive the full impact, and seeing it in action would have gone a long way towards addressing this limitation.

## Conclusion

After receiving assistance from my advisor in the selection and narrowing of a topic, I chose to do my senior capstone project on Cognitively Guided Instruction; the decision was largely based on the fact that my concentration is Mathematics. Following a brief list of MLOs that the capstone would fulfill, the next step was formulating primary and secondary research questions. In summary, these revolved around the origin, definition, and implementation of CGI. The last of these descriptions often flew in the face of traditional math instruction. Other questions dealt with potential benefits that could be gleaned from the practice of CGI principles in other subject areas and explored the compatibility of these principles with various cultures.

Once these questions had been formulated, it was time to get to work. I gathered books from the library at CSUMB through the Voyager search engine, and found numerous online sources. A review of the accumulated literature followed, and the decision was made to concentrate efforts solely on sources with informational content as opposed to adding persuasive arguments for and against CGI implementation. Research was conducted right up to the point where the writing process began in earnest.

The initial secondary research question dealt with the definition and origin of CGI. As stated in fifth volume, issue number 2 of *The Newsletter of the Comprehensive Center – Region VI*, "The emphasis of CGI…is on students' *mathematical* thinking and problem solving strategies and on the *mathematical* demands of the word problems, *not* on teaching behaviors or ready-to-use curriculum" (14). This is definitely a break from traditional math instruction, which relied heavily on lectures and rote computational procedures. In order for CGI to be executed in a successful manner, the teacher must

have a solid understanding of how students think and learn mathematics. The accumulation of this knowledge is the purpose and goal CGI workshops.

An interview conducted with one of the founders of CGI, Professor Elizabeth Fennema, and subsequently published in a newsletter supplied a description of the professional study that eventually morphed into the CGI movement. An investigation of the flaws in traditional math instruction was conducted, followed by an argument for math pedagogy emphasizing understanding.

The CGI approach places a great deal of responsibility on the teacher, who is "constantly 'analyzing students' strategies and deciding what to give them next'" (Brendefur and Foster 17). Fennema and Nelson add, "Using what is learned about a child's mathematical thinking in the classroom to make instructional decisions requires that content, pedagogy, and children's thinking be interconnected" (279). The founders of CGI developed a system to rate and track teacher progress in the pursuit of the ideal CGI classroom. This consisted of Levels 1 – 4, with the fourth level further divided into sublevels of 4A and 4B, with the latter denoting the highest possible level attainable.

Before a new idea can gain full acceptance, it must be determined to be effective. While CGI was found to be extremely effective in attaining its stated goal of enhancing student understanding with no significant loss in computational skills, it should be noted that the research conducted for this paper did not consciously attempt to uncover any sources critical of CGI. To do so in addition to incorporating opposing arguments contained therein was deemed to be beyond the scope of this paper.

The idea of applying CGI principles to other areas of instruction besides mathematics was also explored. It was found that doing so could elicit positive results in

the subjects of reading and language. In addition, CGI is compatible with several cultures, notably those of Native American and Asian origin, due to the nature of the instructional approach techniques.

To conclude the "Results and Discussion" section, general information about the steps to be taken by those who desire to put CGI into action was put forth. The centerpiece of this was the attending of a CGI workshop and the recommendations and requirements pertaining to it. The primary source for all information of this nature is the CC-VI's website, the CGI Spider. Although it includes links to other sites, it should be considered the authoritative source for any CGI needs that schools and their staff might have.

Finally, a section detailing research problems or limitations was detailed. The main limitation was time, for its constraints did not permit me to fully explore the CGI Spider website. In particular, this denied me the opportunity to complete a more comprehensive statistical analysis of the effectiveness of CGI. It also would have been beneficial to conduct an interview of one or more CGI teachers and observe at least one full math period demonstrating its use in a classroom. Few things have more of an impact than a first-hand experience.

As a final note, the emphasis placed on children understanding the arithmetic taught in the classroom cannot be overstated. As Sherian Foster reports, "The most important effect of CGI for children… is that they are learning and 'taking a different kind of look at mathematics [than they have before]. It gives them the ability to understand that they *can* makes [sic] sense of mathematics and that *how* they make sense of mathematics is important" (4, 6). Gloria Ladson-Billings adds, "Too often we treat

students as if they do not have minds – or at least we treat them as if their minds are not sufficient for the kind of intellectual engagement that we value. What CGI offers to teachers – and students – is the opportunity to use their minds well" (9). The last thing teachers should want to do is underestimate the capabilities of their students, for this leads to instruction that does not maximize each child's full potential. It is the teacher's responsibility and highest honor to bring out the very best in each and every student.

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# Appendix A

## CGI in Dearborn, MI

By Jonathan L. Brendefur, Ph.D.
Researcher and Trainer at the Comprehensive Center, Region VI
University of Wisconsin—Madison
June 29, 2000

Many teachers, resource teachers, and principals from Dearborn, Michigan have attended the Comprehensive Center, Region VI's annual CGI Institute and Advanced CGI Institute. During the first year (August, 1998) 17 people attended the first CC-VI CGI Institute held in Madison, Wisconsin. In order for teachers to really implement CGI back in their own schools we suggested in our initial flyer that teams of 2 to 3 teachers at similar grade levels attend along with a specialist. We asked teams to come so that when teachers began trying out ideas they had learned in the Institute they would have already created a small but immediate support group.

District administrators felt impelled to send five teams that consisted of 2 to 5 people from five different elementary schools: Becker, Lowrey, Maples, Mc Donald, and Salina. Over the year, as teachers were implementing CGI in their classrooms, they were able to ask each other questions regarding CGI, write and share problems, and discuss informally what there students were doing.

During the next summer (1999) 5 teachers, 1 principal, and 1 resource teacher attended the Advanced CGI Institute. Here, they learned about CGI in more detail and how to become workshop leaders themselves. In fact, one of them was asked to come back to Madison to held lead one of the initial CGI workshops. She is doing this again this year and plans to help set up and lead a CGI Institute in Dearborn during the summer of 2001.

Later that summer (1999) another 10 participants from Dearborn attended the annual CGI Institute. At this point, there are 28 people in 6 elementary schools involved with CGI: 4 from Becker, 2 from Lowrey, 6 from Maples, 5 from Mc Donalds, 8 from Salina, and 3 from William Ford.

These teachers have also been involved in a research study that has focused on a) understanding the sustainability of an instructional program through a one-week long professional development program and b) whether there are any noticeable differences in their students' mathematics achievement compared to a matched control group. At this point we only have preliminary data, but these data are positive.

Through interview and survey data, teachers have shared how their instructional practices have changed to be more focused on student thinking. They also reported that their attitude about mathematics and teaching mathematics changed. They were more excited about teaching mathematics than in past years and felt that students enjoyed mathematics

more (cheering when it was time to do mathematics) and made other gains other than mathematics achievement. For example, in these Dearborn elementary schools, where over half of the students receive free and reduced lunch and speak Arabic as a first language, these CGI teachers reported that their students' reading and writing skills also increased. They attributed this gain to curricular and instructional changes. For instance, they now give students word problems to solve and subsequently ask them to explain how they solved the problem and whether the strategy made sense. Teachers who taught kindergarten, first, second, and third grade noted these changes and successes.

Achievement data collected over the first year has also been positive. These results show how students in CGI classrooms performed compared to students in non-CGI classrooms. For three grade levels—first, second, and third—fall and spring tests were administered to determine whether there were any differences between Cognitively Guided Instruction (CGI) and Non-CGI students' performances on five different types of problems. The problems were aggregated into five scales. Scale 1 represents easy addition and subtraction problems (e.g., Sara has five cards. She gives two away. How many cards does she have left?). Scale 2 includes more difficult addition and subtraction problems (e.g., Peter bought some marbles. He now has forty-two marbles. How many marbles did Peter have to begin with?). Scale 3 consists of multiplication and division problems (e.g., Seri has four pages of stickers. There are six stickers on each page. How many stickers are there altogether?). Scale 4 includes place value problems (e.g., A pack of gum has ten sticks in it. You bought seven packs. How many sticks of gum do you have altogether?). Scale 5 consisted of traditional addition and subtraction problems (e.g., $13 - 7 = ?$).

The fall test was used as a baseline to determine whether students in CGI classrooms performed similar to students in the control or Non-CGI classrooms. Using statistical tests (t-test for equality of means) there were no significant differences in performance scores between the two different groups (CGI and Non-CGI) of students for any of the grades.

There are three tables presented below that describe the spring differences in students' performances on the five different scales described above. It is important to note that the difference between the CGI and the Non-CGI classrooms is that the teacher in the CGI classrooms attended the one-week long institute in Madison, WI. It is not the case that all the CGI teachers actually taught using cognitively guided instruction. In fact, through interview and survey data, I found that some CGI teachers taught mathematics using this approach only some of the time. In other words, some of the teachers who attended the CGI Institute taught mathematics, at least part of the time, in a similar way as to the Non-CGI teachers. Hence, any positive differences toward CGI would represent the influence of teachers having been at the training. We assume, then, with positive results toward CGI that the more the teachers used CGI as their approach to teaching mathematics the greater the student results would be. However, these tables and this memorandum do not include this type of desegregation.

**Table 1: Overall grade 1 results (Spring 1999)**

| Scales | Class | Mean | S.D. | Sig. | Mean Diff. |
|---|---|---|---|---|---|
| **1. Add/Sub** | Non-CGI | 3.70 | 3.0 | 0.14 | +0.58 |
| | CGI | 4.28 | 3.4 | | |
| **2. Adv Add/Sub** | Non-CGI | 2.73 | 2.9 | 0.84 | +0.69 |
| | CGI | 3.42 | 3.5 | | |
| **3. Mul/Div** | Non-CGI | 1.75 | 2.6 | 0.00* | +1.25 |
| | CGI | 3.01 | 3.5 | | |
| **4. P.Value** | Non-CGI | 2.71 | 2.6 | 0.06 | +0.69 |
| | CGI | 3.40 | 3.3 | | |
| **Overall Performance** | Non-CGI | 5.11 | 4.2 | 0.02* | +1.34 |
| | CGI | 6.47 | 5.3 | | |

*The significance level was set at 0.05 for a two-tailed test
Note: CGI (N = 108), Non-CGI (N = 107)

**Table 2: Overall grade 2 results (Spring 1999)**

| Scales | Class | Mean | S.D. | Sig. | Mean Diff. |
|---|---|---|---|---|---|
| **Scale 1** | Non-CGI | 6.75 | 3.5 | 0.39 | +0.37 |
| | CGI | 7.12 | 3.5 | | |
| **Scale 2** | Non-CGI | 4.82 | 3.5 | 0.13 | +0.68 |
| | CGI | 5.50 | 3.8 | | |
| **Scale 3** | Non-CGI | 2.15 | 2.7 | 0.00* | +1.86 |
| | CGI | 4.01 | 3.0 | | |
| **Scale 4** | Non-CGI | 2.76 | 2.6 | 0.01* | +0.95 |
| | CGI | 3.71 | 2.8 | | |

| | | | | | |
|---|---|---|---|---|---|
| **Scale 5** | Non-CGI | 3.47 | 3.9 | 0.21 | +0.62 |
| | CGI | 4.09 | 4.1 | | |
| **Overall** | Non-CGI | 5.34 | 3.6 | 0.00* | +1.69 |
| **Performance** | CGI | 7.03 | 3.8 | | |

*The significance level was set at 0.05 for a two-tailed test
Note: CGI (N = 132), Non-CGI (N = 134)

**Table 3: Overall grade 3 results (Spring 1999)**

| Scales | Class | Mean | S.D. | Sig. | Mean Diff. |
|---|---|---|---|---|---|
| **Scale 1** | Non-CGI | 7.17 | 4.5 | 0.26 | +1.24 |
| | CGI | 8.42 | 3.7 | | |
| **Scale 2** | Non-CGI | 5.86 | 3.7 | 0.19 | +1.23 |
| | CGI | 7.10 | 3.8 | | |
| **Scale 3** | Non-CGI | 4.91 | 3.2 | 0.03* | +1.66 |
| | CGI | 6.57 | 2.6 | | |
| **Scale 4** | Non-CGI | 4.45 | 3.2 | 0.01* | +2.12 |
| | CGI | 6.57 | 3.14 | | |
| **Overall** | Non-CGI | 4.91 | 2.79 | 0.01* | +1.82 |
| **Performance** | CGI | 6.74 | 2.64 | | |

*The significance level was set at 0.05 for a two-tailed test
Note: CGI (N = 92), Non-CGI (N = 19)

There are two major points to make regarding the tables. First, notice that there is a positive trend in students' performances from CGI classrooms. This trend is noted for each scale, for the overall performance on the test, and at each grade level. Second, students in CGI classrooms statistically (and significantly to a 0.05 level) outperformed students in Non-CGI classrooms (a) on multiplication and division problems in grades 1, 2, and 3, (b) on place-value related problems in grades 2 and 3, and (c) on their overall performance of the test in grades 1, 2 and 3.

# Appendix B

## CGI in Lansing, MI

Jonathan L. Brendefur, Ph.D.
Researcher and Trainer at the Comprehensive Center, Region VI
University of Wisconsin—Madison
June 29, 2000

Achievement data collected over the first year has also been positive. Here are some results from the Lansing Elementary schools, which have participated in our testing.

For all three grade levels—first, second, and third—fall and spring tests were administered to determine whether there were any differences between Cognitively Guided Instruction (CGI) and Non-CGI students' performances on five different types of problems. The problems were aggregated into five scales. Scale 1 represents easy addition and subtraction problems (e.g., Sara has five cards. She gives two away. How many cards does she have left?). Scale 2 includes more difficult addition and subtraction problems (e.g., Peter bought some marbles. He now has forty-two marbles. How many marbles did Peter have to begin with?). Scale 3 consists of multiplication and division problems (e.g., Seri has four pages of stickers. There are six stickers on each page. How many stickers are there altogether?). Scale 4 includes place value problems (e.g., A pack of gum has ten sticks in it. You bought seven packs. How many sticks of gum do you have altogether?). Scale 5 consisted of traditional addition and subtraction problems (e.g., $13 - 7 = ?$).

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greater the student results would be. However, these tables and this memorandum do not include this type of desegregation.

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| | CGI | 3.01 | 3.5 | | |
| Scale 4 | Non-CGI | 2.71 | 2.6 | 0.06 | +0.69 |
| | CGI | 3.40 | 3.3 | | |
| Overall Performance | Non-CGI | 5.11 | 4.2 | 0.02* | +1.34 |
| | CGI | 6.47 | 5.3 | | |

*The significance level was set at 0.05 for a two-tailed test
Note: CGI (N = 108), Non-CGI (N = 107)

**Table 2: Overall grade 2 results (Spring 1999)**

| Scales | Class | Mean | S.D. | Sig. | Mean Diff. |
|---|---|---|---|---|---|
| Scale 1 | Non-CGI | 6.75 | 3.5 | 0.39 | +0.37 |
| | CGI | 7.12 | 3.5 | | |
| Scale 2 | Non-CGI | 4.82 | 3.5 | 0.13 | +0.68 |
| | CGI | 5.50 | 3.8 | | |
| Scale 3 | Non-CGI | 2.15 | 2.7 | 0.00* | +1.86 |
| | CGI | 4.01 | 3.0 | | |
| Scale 4 | Non-CGI | 2.76 | 2.6 | 0.01* | +0.95 |

| | | | | | |
|---|---|---|---|---|---|
| | CGI | 3.71 | 2.8 | | |
| Scale 5 | Non-CGI | 3.47 | 3.9 | 0.21 | +0.62 |
| | CGI | 4.09 | 4.1 | | |
| Overall | Non-CGI | 5.34 | 3.6 | 0.00* | +1.69 |
| Performance | CGI | 7.03 | 3.8 | | |

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Note: CGI (N = 132), Non-CGI (N = 134)

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| | CGI | 8.42 | 3.7 | | |
| Scale 2 | Non-CGI | 5.86 | 3.7 | 0.19 | +1.23 |
| | CGI | 7.10 | 3.8 | | |
| Scale 3 | Non-CGI | 4.91 | 3.2 | 0.03* | +1.66 |
| | CGI | 6.57 | 2.6 | | |
| Scale 4 | Non-CGI | 4.45 | 3.2 | 0.01* | +2.12 |
| | CGI | 6.57 | 3.14 | | |
| Overall | Non-CGI | 4.91 | 2.79 | 0.01* | +1.82 |
| Performance | CGI | 6.74 | 2.64 | | |

*The significance level was set at 0.05 for a two-tailed test
Note: CGI (N = 92), Non-CGI (N = 19)

There are two major points to make regarding the tables. First, notice that there is a positive trend in students' performances from CGI classrooms. This trend is noted for each scale, for the overall performance on the test, and at each grade level. Second, students in CGI classrooms statistically (and significantly to a 0.05 level) outperformed students in Non-CGI classrooms (a) on multiplication and division problems in grades 1, 2, and 3, (b) on place-value related problems in grades 2 and 3, and (c) on their overall performance of the test in grades 1, 2 and 3.

The next set of tables is a subset of this larger group and focuses on all the teachers within the Lansing School District who participated in the study. Although Lansing has been involved in the testing process for two years, the data only reflects the first year scores since the spring data for year two is currently being collected. In addition, there is not a table for grade 3 since only one teacher in Lansing was involved in the testing – hence, no comparison class.

The data for Lansing teachers is not much different from the overall data. For grade 1 (see Table 4), students in CGI classrooms statistically outperformed students in Non-CGI classrooms in (a) advanced addition and subtraction problems, (b) multiplication and division problems and (c) overall performance. In addition, student performances tended to be higher on all the scales if they were in CGI classrooms.

Second grade data again showed a consistent positive pattern of performance toward CGI classrooms for all scales. CGI students significantly outperformed students in Non-CGI classes on multiplication and division.

In sum, it appears that students in teachers' classrooms who have attended the CGI Institute do better than students in teachers' classrooms without this knowledge.

**Table 4: Grade 1 results for Lansing (Spring 1999)**

| Scales | Class | Mean | S.D. | Sig. | Mean Diff. |
|---|---|---|---|---|---|
| Scale 1 | Non-CGI | 4.48 | 3.3 | 0.12 | +1.29 |
|  | CGI | 5.77 | 3.2 |  |  |
| Scale 2 | Non-CGI | 3.20 | 2.9 | 0.03* | +1.87 |
|  | CGI | 5.07 | 3.4 |  |  |
| Scale 3 | Non-CGI | 1.90 | 2.5 | 0.01* | +2.30 |
|  | CGI | 4.20 | 3.8 |  |  |
| Scale 4 | Non-CGI | 4.05 | 3.0 | 0.17 | +1.10 |
|  | CGI | 5.16 | 3.2 |  |  |
| Overall | Non-CGI | 6.52 | 4.2 | 0.03* | +2.75 |
| Performance | CGI | 9.27 | 5.1 |  |  |

*The significance level was set at 0.05 for a two-tailed test
Note: CGI (N = 44), Non-CGI (N = 25)

**Table 5: Grade 2 results for Lansing (Spring 1999)**

| Scales | Class | Mean | S.D. | Sig. | Mean Diff. |
|---|---|---|---|---|---|
| **Scale 1** | Non-CGI | 6.87 | 3.5 | 0.16 | +1.04 |
| | CGI | 7.91 | 2.7 | | |
| **Scale 2** | Non-CGI | 6.08 | 3.5 | 0.63 | +0.39 |
| | CGI | 6.48 | 3.6 | | |
| **Scale 3** | Non-CGI | 3.25 | 3.1 | 0.05* | +1.37 |
| | CGI | 4.62 | 3.1 | | |
| **Scale 4** | Non-CGI | 3.80 | 2.9 | 0.34 | +0.64 |
| | CGI | 4.44 | 3.0 | | |
| **Scale 5** | Non-CGI | 4.50 | 4.35 | 0.82 | +0.22 |
| | CGI | 6.80 | 3.8 | | |
| **Overall Performance** | Non-CGI | 8.28 | 3.5 | 0.08 | +1.48 |
| | CGI | | | | |

*The significance level was set at 0.05 for a two-tailed test
Note: CGI (N = 76), Non-CGI (N = 40)

# Appendix C

## CGI STUDENT ACHIEVEMENT IN REGION VI EVALUATION FINDINGS

### [ walter g. secada and jonathan l. brendefur ]

IMPLEMENTING A PROFESSIONAL DEVELOPMENT PROGRAM WITH A PROVEN TRACK RECORD PROVIDES SOME ASSURANCE THAT STUDENT ACHIEVEMENT IN MATHEMATICS WILL IMPROVE. FOR EXAMPLE, VILLASENOR AND KEPNER (1993) FOUND THAT URBAN FIRST GRADERS WHOSE TWELVE TEACHERS HAD RECEIVED PROFESSIONAL DEVELOPMENT BASED ON COGNITIVELY GUIDED INSTRUCTION (CGI) OUTPERFORMED A MATCHED GROUP OF STUDENTS WHOSE TEACHERS HAD NOT PARTICIPATED IN THE SAME PROFESSIONAL DEVELOPMENT. ANALYSIS OF COVARIANCE REVEALED THAT, ON AVERAGE, CGI STUDENTS OUTPERFORMED COMPARISON STUDENTS BY: (A) 3 STANDARD DEVIATIONS ON NUMBER FACTS, (B) 4.11 STANDARD DEVIATIONS WHEN SOLVING WORD PROBLEMS IN ONE-TO-ONE (TEACHER-TO-STUDENT) INTERVIEWS, AND (C) 6.63 STANDARD DEVIATIONS WHEN SOLVING WRITTEN WORD PROBLEMS. THESE RESULTS ARE ASTOUNDING, RECALLING THAT A DIFFERENCE OF ONE HALF OF ONE STANDARD DEVIATION IS CONSIDERED LARGE. (SEE STATISTICAL NOTE NEXT PAGE.)

Findings such as these, however, cannot replace the need to carefully monitor the implementation of a program and the actual achievement of students in that program, which is what Comprehensive Center – Region VI did. More than 110 teachers have participated in the Comprehensive Center-sponsored CGI Institutes that provided initial professional development on the teaching of mathematics to at-risk students. The Center invited these teachers to participate in an evaluation of the program in their classrooms. Participation in the evaluation was completely voluntary and did not affect teachers' participation in any of the CGI Institutes nor their receiving follow-up support.

#### Cooperating Teachers

Over the course of two years, 63 first-grade teachers (34 CGI, 29 non-CGI), 48 second-grade teachers (24 CGI, 24 non-CGI), and 31 third-grade teachers (17 CGI, 14 non-CGI) participated in the evaluation. Of the 110 CGI teachers involved in the first two years' CGI Institutes, 75 participated, at some point, in the evaluation. The evaluation teachers came from throughout Region VI, with most teaching in the region's urban, small urban, and rural districts. CGI teachers invited same-grade, non-CGI colleagues who were teaching right next door to participate in the evaluation, thereby creating a matched comparison group.

This method mitigates against finding very strong positive treatment effects since the non-CGI teachers — as they visited their colleagues' classrooms and observed what the CGI teachers and their students were doing — eventually started teaching like the CGI teachers. (See Dearborn, Michigan — A System Changes, in this newsletter.) Interestingly, non-CGI teachers asked to participate in the CGI Institutes so that, at present, almost all of the comparison teachers have become CGI teachers.

#### Students

Assuming an average class size of 25 students, CGI teachers have taught more than 4,000 students during the first two years of CC – VI involvement offering CGI Institutes and followup services. Over the two-year course of this evaluation, the Comprehensive Center gathered mathematics achievement data on 986 first graders, 741 second graders, and 365 third graders. Complete fall and spring achievement data are available for a smaller sample of students consisting of 745 first graders (423 CGI, 322 non-CGI), 514 second graders (303 CGI, 211 non-CGI), and 324 third graders (186 CGI, 138 non-CGI). The population of students includes poor Caucasian children, African American children, American Indian children, Hispanic children, Southeast Asian children, Arabic children, and children learning English as a second language.

#### Gathering and Analyzing Data

This evaluation used the written mathematics assessments which had been created for a longitudinal evaluation of CGI by its original developers (Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996). In the fall of each year, teachers administered the assessment for the previous grade and, in the spring, administered the assessment for that grade. For example, in the fall, first graders took the kindergarten assessment, then, in the spring, they took the first grade assessment.

#### Scales and Scoring

Teachers read the problems aloud, in English, to the entire class. If children had questions or did not understand something about the problem, teachers reread the problem.

- Assessment items were scored either correct or incorrect.
- The data analysis was based on the following scales.
- A student's score on each scale was the percentage of items answered correctly.

## STATISTICAL NOTE:

### Standard Deviations

Standard deviations are often used to describe differences between groups when the assessment instrument may be unfamiliar to the reader. This metric allows the reader to judge the difference between groups based on the spread of performance within groups. A difference of one half of one standard deviation is considered to be large since, in a normal distribution, approximately 68% of the scores fall within one standard deviation of the mean and about 95% of all scores fall within two standard deviations of the mean. By way of comparison, the SAT is normed so that a standard deviation is 100 points.

### Effect Size

Effect size is computed by dividing the difference between the two groups' by the standard deviation of the comparison group. An effect size of .50, for example, indicates that the groups differed by one half of one standard deviation.

Finally, *p* is the probability that the difference between the two groups is a random difference. The smaller the value of *p*, the more likely the difference between groups is *not* due to chance - the more likely, in this case, it is due to learning mathematics in a CGI classroom.

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[ about the author ]

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## SCALES

1. Overall Performance
   (all assessment items)

### WORD PROBLEMS

Successfully solving word problems for a given scale requires the stated mathematical understandings/skills. Examples of problems on each scale follow in the presentation of results.

2. Simple Addition and Subtraction
3. Complex Addition and Subtraction
4. Multiplication and Division
5. Place Value

### COMPUTATIONS

This scale measured basic computational skills. Items in this category were "naked" computations — computations devoid of context.

6. Multi-Digit Computations

NOTE: ASSESSMENT ITEMS MAY FIT INTO MORE THAN ONE SCALE FOR EXAMPLE, A PROBLEM MAY BE CLASSIFIED AS A COMPLEX ADDITION AND SUBTRACTION WORD PROBLEM (SCALE 3) AND AS A WORD PROBLEM REQUIRING PLACE VALUE KNOWLEDGE (SCALE 5). ON SUCH ITEMS, THE STUDENT'S SCORE DOES NOT COUNT MORE THAN ONCE IN THE OVERALL PERFORMANCE (SCALE 1).

### RESULTS

Evaluation results are based on analysis of covariance in which the spring scores on overall performance and on all subscales are covaried on the fall scores on the corresponding scales. While such analysis tells an important part of the story, it is only part of the story. For that reason, we also present examples from the problems on which CGI and non-CGI differed.

## ANALYSIS OF COVARIANCE — FIRST GRADE

| Scale | CGI Students (n=43) | | Non-CGI Students (n=32) | | EFFECT SIZE |
|---|---|---|---|---|---|
| | %CORRECT | STANDARD DEVIATION | %CORRECT | STANDARD DEVIATION | |
| 1. Overall Performance | 46% | 28 | 40% | 26 | .24 (p<.001) |
| WORD PROBLEM | | | | | |
| 2. Simple Addition & Subtraction | 60% | 32 | 53% | 32 | .19 (p<.025) |
| 3. Complex Addition & Subtraction | 48% | 36 | 41% | 33 | .21 (p<.013) |
| 4. Multiplication & Division | 43% | 35 | 34% | 34 | .26 (p<.001) |
| 5. Place Value | 45% | 34 | 39% | 31 | .29 (p<.001) |
| COMPUTATION | | | | | |
| 6. Computation | 15% | 30 | 9% | 23 | .27 (p<.001) |

### Percent Correct on Selected Items

**FIRST GRADE**

WORD PROBLEMS

CGI students outperformed non-CGI students in all categories.

2. Simple Addition and Subtraction

Paco had 13 cookies. He ate 6 of them. How many cookies did Paco have left?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 74% |
| Non-CGI | 67% |

Misha had 23 pennies. She spent 8 pennies on candy. How many pennies did Misha have left?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 55% |
| Non-CGI | 41% |

3. Complex Addition and Subtraction These problems go beyond what is found in the conventional first grade mathematics curriculum.

Chris had 18 marbles. He bought 25 more marbles. How many marbles does Chris have altogether?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 48% |
| Non-CGI | 33% |

John has 38 dollars. How many more dollars does he have to save to have 58 dollars?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 41% |
| Non-CGI | 30% |

4. Multiplication and Division Word Problems These problems are not part of the conventional first grade mathematics curriculum.

There are 24 children in Ms. Tate's class. The class was divided into 4 teams with the same number of children on each team. How many children were on each team?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 36% |
| Non-CGI | 20% |

5. Place Value

Fay has 3 packages of gum. There are 6 pieces of gum in each package. How many pieces of gum does Fay have altogether?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 53% |
| Non-CGI | 42% |

COMPUTATIONS

6. Computations These multi digit computations also go beyond what is found in the conventional first grade curriculum.

239 + 564 =

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 13% |
| Non-CGI | 1% |

INTERPRETING EVALUATION RESULTS

The statistical and individual problem results paint a dual picture. On one hand, students taught using the CGI program outperformed non-CGI students across the board. Yet even on more difficult problems that are not taught in conventional first grade mathematics, non-CGI students showed a greater level of competence than is typically ascribed to first graders — especially to at-risk students.

## ANALYSIS OF COVARIANCE — SECOND GRADE

| Scale | CGI Students (n=?) | | Non-CGI Students (n=?) | | EFFECT SIZE |
|---|---|---|---|---|---|
| | %CORRECT | STANDARD DEVIATION | %CORRECT | STANDARD DEVIATION | |
| 1. Overall Performance | 59% | 27 | 52% | 28 | .29 (p<.019) |
| WORD PROBLEM | | | | | |
| 2. Simple Addition & Subtraction | 80% | 33 | 74% | 35 | .17 (not significant) |
| 3. Complex Addition & Subtraction | 60% | 33 | 59% | 34 | .21 (p<.026) |
| 4. Multiplication & Division | 55% | 34 | 43% | 36 | .34 (p<.001) |
| 5. Place Value | 52% | 33 | 48% | 33 | .17 (not significant) |
| COMPUTATION | | | | | |
| 6. Computation | 15% | 30 | 9% | 23 | .27 (p<.001) |

### Percent Correct on Selected Items

**SECOND GRADE**

WORD PROBLEMS

CGI students outperformed non-CGI students in all categories.

2. Simple Addition and Subtraction CGI and non-CGI students performed comparably well. These problems are typical of what is usually found in the second grade mathematics curriculum.

Chris had 28 marbles. He bought 35 more marbles. How many marbles does Chris have altogether?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 80% |
| Non-CGI | 70% |

3. Complex Addition and Subtraction CGI students outperformed non-CGI students. These problems are part of the conventional second grade mathematics curriculum.

Pat has 26 baseball cards. How many more baseball cards does Pat need to collect to have 51 baseball cards altogether?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 56% |
| Non-CGI | 46% |

John has 238 dollars. How many more dollars does he have to save to have 258 dollars?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 55% |
| Non-CGI | 44% |

4. Multiplication and Division Word Problems CGI students outperformed non-CGI students. These problems are not part of the conventional second grade mathematics curriculum.

There are 24 children in Ms. Tate's class. The class was divided into 4 teams with the same number of children on each team. How many children were on each team?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 64% |
| Non-CGI | 38% |

NOTE: OF THE CGI STUDENTS, 38% COULD SOLVE THIS PROBLEM AT THE END OF FIRST GRADE. THIS SUGGESTS THAT CGI STUDENTS MIGHT BE ACCELERATED ONE FULL YEAR RELATIVE TO THEIR NON-CGI PEERS ON THE DEVELOPMENT OF MULTIPLICATION AND DIVISION CONCEPTS.

A worm can crawl 4 inches in a minute. How far can the worm crawl in 8 minutes?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 42% |
| Non-CGI | 25% |

5. Computations

CGI and non-CGI students performed comparably well. These multi digit problems are typical of what is usually found in the conventional second grade mathematics curriculum.

239 + 564 =

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 50% |
| Non-CGI | 46% |

INTERPRETING EVALUATION RESULTS

The second grade statistical and individual problem results paint a complex picture. CGI students perform as well as non-CGI students on content that is taught in the conventional curriculum. On advanced and more demanding content, however, they outperformed their non-CGI peers and, in some cases, might be advanced by one year. It also bears noting that, even on more difficult problems that are not taught in conventional second grade mathematics, non-CGI students showed a greater level of competence than what is typically ascribed to second grade at-risk students.

## ANALYSIS OF COVARIANCE — THIRD GRADE

| Scale | CGI Students (n=?) | | Non-CGI Students (n=?) | | EFFECT SIZE |
|---|---|---|---|---|---|
| | %CORRECT | STANDARD DEVIATION | %CORRECT | STANDARD DEVIATION | |
| 1. Overall Performance | 70% | 26 | 57% | 27 | .29 (p<.001) |
| WORD PROBLEM | | | | | |
| 2. Simple Addition & Subtraction | 83% | 37 | 77% | 42 | .15 (not significant) |
| 3. Complex Addition & Subtraction | 73% | 37 | 62% | 37 | .29 (p<.001) |
| 4. Multiplication & Division | 69% | 31 | 52% | 32 | .53 (p<.001) |
| 5. Place Value | 67% | 33 | 55% | 33 | .38 (p<.001) |
| COMPUTATION | | | | | |
| 6. Computation | 75% | 34 | 69% | 35 | .11 (p<.001) |

### Percent Correct on Selected Items

**THIRD GRADE**

WORD PROBLEMS

On word problems requiring simple and addition and subtraction (Scale 2) and on naked computations (Scale 6), CGI and non-CGI third graders performed comparably well. Problems in both of these categories are found in conventional third grade mathematics.

3. Complex Addition and Subtraction CGI third graders outperformed their non-CGI peers.

Pat has 26 baseball cards. How many more baseball cards does Pat need to collect to have 51 baseball cards altogether?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 70% |
| Non-CGI | 59% |

4. Multiplication and Division Word Problems CGI students outperformed their non-CGI peers. Problems like these become more prominent in the third grade mathematics curriculum.

A worm can crawl 4 inches in a minute. How far can a worm crawl in 8 minutes?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 75% |
| Non-CGI | 54% |

Note: Of CGI second graders, 42% answered this problem correctly.

There are 52 children in the third grade. The third grade was divided into 4 teams with the same number of children on each team. How many children were on each team?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 50% |
| Non-CGI | 41% |

Fay has 4 packages of gum. There are 13 pieces of gum in a package. How many pieces of gum does Fay have altogether?

| Students | Percent Correct |
|---|---|
| CGI | 77% |
| Non-CGI | 61% |

5. Place Value CGI students outperformed non-CGI students.

Misha has 238 dollars. How many more dollars does he have to save to have 258 dollars?

| STUDENTS | PERCENT CORRECT |
|---|---|
| CGI | 76% |
| Non-CGI | 64% |

INTERPRETING EVALUATION RESULTS

CGI students have no trouble keeping up with their peers on content that is found in the conventional third-grade curriculum. However, when solving problems involving content that is not conventionally taught during third grade — content that, in fact, goes beyond what is typically taught in third grade — CGI students outperformed their non-CGI peers. Moreover, in third grade that difference in performance reached one half (.5) of one standard deviation, the largest margin by which CGI students outperformed their non-CGI peers. This suggests that, in terms of student achievement, CGI may prove to have increasing benefits as grade level increases.