Student data reflecting the effectiveness of the CIMM program at Hidden Hills Elementary School

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The Paradise Valley Unified School District in Arizona, in northern Phoenix, has been administering Standard Aligned Measures (SAM) tests in mathematics since 2005. The SAMs tests, three during the year, have shown a high degree of correlation with the state’s “Arizona’s Instrument to Measure Standards” (AIMS) tests. Thus any improvement on a SAM test can be expected to show up as positive gain on state AIMS scores.

The design of this study is to take an intact class of students and use a first quarter of standard instruction to establish a baseline for student performance with respect to district norms using SAM 1st quarter test. Once the baseline has been established, this baseline can be used to predict future performance on SAMs tests if no instructional or program changes are made. However, in the class studied, a third-grade class at Hidden Hills Elementary School, both the program and pedagogy were changed after the second month of instruction and administration of the SAM 1st quarter test, from standard instruction to Cognitive Instruction in Mathematical Modeling (CIMM).

The CIMM program involves both a curriculum and pedagogy, and these two factors cannot be separated for analysis because the pedagogy is tightly linked to the curriculum materials. Since it is not possible to separate them, any changes in outcomes will be the result of multiple factors. This study has the advantage in that the control is not another class with similar demographics but rather the response that this class has to introduction of the new curriculum compared to its own performance prior to its introduction, and in comparison to school district performance and performance of comparison classes over the same two periods of time.

Background Information: Hidden Hills Elementary School (HHE), an upper middle class suburban school, has three classes of grade three students, taught by three different teachers. Students are assigned to a class according to perceived ability; for purposes of mathematics instruction the three groups are called enriched, regular and low. The grade three “low group” teacher, whose teaching assignment had been changed from grade one in 2007-2008 to grade three for 2008-2009, was encouraged to upgrade her math skills by enrolling in a CIMM workshop offered by the school district. Two months after the 2008 fall semester began, she started attending a weekly after-school teacher workshop on Cognition Ignition, a pre-algebra math course based on CIMM. (The course had started three weeks earlier, but she missed the first three weekly sessions.) After one month of learning CIMM while teaching in a conventional way, she made the transition to using the CIMM material in her class with the guidance of a person trained in CIMM pedagogy.
The study: The only difference between the first and second quarter was the use of CIMM Cognition Ignition materials and pedagogy. The enriched and regular groups meanwhile used standard instruction during both quarters. All three groups were taught math for about an hour each day. The low group had twenty-seven students (including seven special education students), the regular group twenty-five, and the enriched group twenty-nine. The evaluation was done using the district-wide assessment instruments known as SAM-1 and SAM-2.

Results:

Overall: The average low group score on SAM-1 was 73%, which was slightly higher than the district average of 71%. The average low group score on SAM-2 was 82%, significantly higher than the district average of 70%. The regular group scores increased from 75% to 77%. The enriched group scores dropped four percentage points, from 82% to 78%. See Chart I.

![Chart 1: A comparison of average grade three scores for low, regular and enriched groups at Hidden Hills Elementary School and for the school district on the SAM-1 test at the end of October 2008 and on the SAM-2 test in late December 2008.](chart1.jpg)

Subsections of SAM:
SAM-2 covers somewhat different material than SAM-1; however there are some overlaps. The number sense subsection of SAM-2 has the greatest overlap with SAM-1. On this subsection the low group average of 81% was significantly higher than the district average of 70%. For the district as a whole, however, there was no change on this subsection.
The “data, probability and statistics” subsection of SAM-2 is comprised of only two questions. The district average on these two questions was 35%. The enriched group average was 57%. The low group (CIMM) average was 81%. These two questions are identical mathematically but different contextually. The district scores differed significantly on these questions: 27% on the first and 43% on the second. The enriched group scores also differed greatly: 38% and 76%. The regular group differed the most: 36% and 92%. *Almost all CIMM students who correctly answered the first question also correctly answered the second question.*

On SAM-2, the highest district average of 83% was on the “patterns, algebra and functions” subsection. *The low group average on this section was 78%.* This is because the low group performed poorly on patterns, questions 4 and 17, which were not covered by instruction. See Chart II. *On the “geometry and measurement” subsection the low group average was 89%, whereas the district average was 69%. Some of this material was not taught to the CIMM class.*

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**Test Item Scores**  
(Low Group and District)

![Bar chart showing test item scores for low group and district](chart2.png)

Chart II: a comparison of school district and low group scores for each question.

**Individual student progress in the low group:**  
Twelve students increased their average by more than 15 percentage points (Students 16-27 in Chart III), four by more than 25 percentage points (Students 24-27) and one by 40 percentage points (Student 27). Many students who were lagging before are now excelling. One special needs student (Student 1) dropped by 40 percentage points. This student only got one correct out of eight questions on number sense, which was the main focus of the earlier test on which s/he scored 60%. This student has a severe language disability and SAM-2 required a sophisticated level of reading skills whereas SAM-1 did not. Student 2 had similar problems but to a lesser degree.
Chart III indicates individual low group student progress from the end of the first quarter to the end of the second quarter.

![Chart III](image)

Chart III: individual low group student progress from the end of the first quarter to the end of the second quarter.

**Discussion and Analysis:**

An examination of the test papers of the low group showed that some students were able to symbolize and then solve the problem. For example, on a question concerning basketball, one student symbolized each “basket made” by the basketball player as a group of two dots and another as a star. Many students symbolized multiplication and division questions by groups of dots. This approach of symbolizing the problem and then solving it is quite unique at this grade level.

The scores on the “data, probability and statistics” subsection indicate that low group students were able to transfer their mathematical understanding from one context to another in a way that was unmatched by either the regular or enriched groups, as indicated by their ability to solve both of these problems with equal facility. Students in the other groups differed greatly in their results on these two problems. It appears that students who were exposed to the CIMM program were able to form an understanding of the underlying structure of these types of problems.
The performance of CIMM students on the geometry questions can be understood in the context of transfer. The students appear to have correctly applied a conceptual tool (one of the CIMM program’s sophisticated tools for constructing mathematical concepts, the trichotomy “the same, not the same, the same but not the same”) on questions 10 and 11, which could easily be answered by this reasoning.

The change illustrated in this study is not due to any single component, but rather can be attributed to a combination of having the students build their own mathematical ideas by using sophisticated conceptual tools and having them learn to represent those ideas using representational tools, and to a pedagogy that involves student presentations with Socratic dialogue. In addition there is a strong focus on conceptual and linguistic understanding, symbol manipulation and problem solving. Taken together, these reflect a shift in understanding of the nature of mathematics and the way in which it is learned.

Beyond producing higher test scores, benefits of CIMM include a dramatic shift in student attitude as indicated by an attitude assessment questionnaire. Thirteen of twenty students reported that before this program mathematics was “hard and confusing” or similar statements. However, all of the students reported that CIMM made math easier. Their frequent use of the word “love” in their written comments indicates an overall enthusiasm for doing mathematics and strongly suggests that their perception of mathematics as hard and confusing has changed. Other student comments to the effect that now if they don’t know the answer they can work it out, indicate a deeper understanding of mathematical processes and an awareness of having this deeper understanding.

The effect on the teacher who introduced this program to her low group was also striking. By her own admission, she previously hated math and found it difficult to teach. Her experience teaching Cognition Ignition for two months has had a dramatic impact on her attitude. She reports that she now loves math and finds that this is her most enjoyable topic to teach. In fact, she is now talking about taking more math classes and becoming a math specialist.

**Conclusion:**

This study is unusual in that it has documented that it is possible to take an under-performing group of students containing a significant number of special education students, some diagnosed and some not, and transforming it into a high-performing group. This was not accomplished by focusing instruction strictly on the standards to be tested. The focus was rather on developing student understanding, and that required a paradigm shift in thinking about the nature of mathematics and how an understanding of mathematics is to be acquired. This can be seen in the illustrations of low group student work in Diagrams I, II and III.

The study is unusual also in that it has shown a transformation in both student and teacher attitudes about mathematics and in their willingness to engage in doing it.
The third unusual aspect of this study is the time frame of nine weeks for the effect to take place. The factors that are causing this might be the enthusiasm for doing math, the level of engagement and the retention from day to day.

This has been accomplished even though CIMM, as a program, is more complicated, rigorous, and requires significantly more reasoning. One possible reason for the success of this program is that CIMM materials are engineered to activate and coordinate different parts of the brain simultaneously, and consequently are experienced by the student as making sense.

This study does not represent an experiment in the sense that these results can be duplicated in any other classroom. What can be duplicated is the overall enthusiasm of students and improved scores on assessments. CIMM offers hope that a difference can be achieved for all learners.

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\[(5 \times 5) + 1 = 26\]

\[\omega = 5 \times (5 \times 5 + 1)\]

\[\frac{5 \times 11}{5} \div 5 = 5\]

The whole is five groups of five dots plus one group of one dot.

\[26 \div 5 = 5.2\]

Diagram 1
Diagram II

The table is for presentation of results.

and grouped the data.

If used in your analysis of student data.

$$\frac{50}{y} = 12 \div 2$$

$$\frac{50}{y} = 12 \div 2$$

$$\frac{50}{y} = 12 \div 2$$

$$\frac{50}{y} = 12 \div 2$$

$$y = 50$$

$$(y \times 12) + 2 = 50$$

math

09/19/19

50
Diagram III