

Chapter 5: Summary and Conclusions

The overall purpose of this study was to investigate the joint impact on mathematics course-taking and high school algebra achievement of a semestered block schedule and a mathematics curriculum designed to conform with the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). The case of one particular school, Suburban High School, was examined in detail. During the 1996-97 school year, Suburban high school initiated a semestered block schedule for all ninth graders. In that same year, ninth graders were enrolled in IMP, as a phase-in of this new reform-based curriculum.

Summary of Results on the Algebra Achievement Test

In the spring of 1997, eleventh graders at Suburban High school completed a three part Algebra Achievement test. The eleventh graders tested in the spring of 1997 had used a traditional schedule and traditional curriculum throughout Grades 9 through 11. They form a “Traditional” cohort that was contrasted with later “Reform” cohorts.

The testing was repeated in the spring of 2000 and the spring of 2001. Students tested in those years had used a semestered block schedule and the IMP curriculum throughout Grades 9 through 11. They comprise the two “Reform” cohorts who completed the Algebra Achievement test.

The Algebra Achievement test was comprised of three sub-tests. Test 1 measured achievement on understanding and solving applied algebra problems in context. Students had access to graphing calculators while completing Test 1. Test 2 measured achievement on algebra symbol manipulation without context or access to graphing

calculators. Test 3 was completed by students working in pairs. It measured their ability to solve a single, complex, open-ended, applied algebra problem.

Sixth-grade test scores were used as a covariate to control for prior student ability. Optimum Least Squares Linear Regression was used to investigate differences between students in the Reform cohorts and students in the Traditional cohort on Test 1 and Test 2. A Probit analysis was used to investigate differences between students in the Reform cohorts and students in the Traditional cohorts on Test 3. After controlling for prior ability, there is 95% confidence that the following three statements are simultaneously true:

1. On Test 1, the test of understanding and solving applied algebra problems in context, the mean score of students in the Reform cohorts differed from what would have been likely for the same students had they been in the Traditional cohort by between +1.3% and +9.3% correct. In standard deviation terms, this confidence interval was between +0.06 and +0.40 standard deviations. This was a statistically significant difference in favor of the Reform cohorts, as reflected by the fact that the Bonferroni-adjusted confidence interval contains only positive numbers, with the probable impact of being in a Reform cohort ranging from a very small positive effect to a moderate positive effect.
2. On Test 2, the test of symbol manipulation without context or access to graphing calculators, the mean score of students in the Reform cohorts differed from what would have been likely for the same students had they been in the Traditional cohort by between -9.4% and +0.6% correct. In

standard deviation terms, this confidence interval was between -0.36 and $+0.02$ standard deviations. This was a statistically non-significant difference, as reflected by the fact that the Bonferroni-adjusted confidence interval contains both negative and positive numbers, with the probable impact of being in a Reform cohort ranging from a moderate negative effect to a very small positive effect.

3. On Test 3, the test that required pairs of students to solve a single, complex, open-ended, applied algebra problem, the mean achievement of student pairs in the Reform cohorts differed from what would have been likely for the same pairs had they been in the Traditional cohort by between $+0.05$ and $+0.74$ standard deviations. This was a statistically significant difference in favor of the Reform cohorts, as reflected by the fact that the Bonferroni-adjusted confidence interval contains only positive numbers, with the probable impact of being in a Reform cohort ranging from a very small positive effect to a fairly large positive effect.

After controlling for prior ability, the average effect size of being in the Reform cohort on understanding and solving applied algebra problems (Test 1) was $+0.23$ standard deviations, enough to move a student who would ordinarily score at the 50th percentile up to the 59th percentile. The average effect size of being in the Reform cohort on algebraic symbol manipulation problems (Test 2) was -0.17 standard deviations, enough to move a student who would ordinarily score at the 50th percentile down to the 43rd percentile. The average effect size of being in the Reform cohort on a pair's ability to solve an extended open-ended applied algebra problem (Test 3) was $+0.40$ standard

deviations, enough to move a pair who would ordinarily score at the 50th percentile of all pairs up to the 66th percentile.

On Test 1 and Test 2, the effects of being in a Reform cohort appeared to be the same regardless of prior ability. That is, achievement of both high-ability and low-ability students appeared to respond in the same way to membership in the Traditional or Reform cohort. On Test 3, the picture was more complicated. For many pairs of students who took the test, a sixth-grade ability estimate was available for only one member of the pair. When all pairs with any ability estimate were included in the analysis, there appeared to be no interaction with prior ability. When only pairs who had two Grade 6 ability estimates were included in the sample, there did appear to be an interaction, with membership in the Reform cohorts having a more pronounced positive effect on students of lower ability. One possible explanation for the fact that applying differing definitions to measure prior achievement yielded differing results in the test of ability-by-treatment interactions is suggested by the fact that students with a missing measure on Grade 6 achievement were frequently those students who had not attended Suburban High School's feeder middle school. An innovative mathematics curriculum, *Visual Mathematics* (Foreman & Bennett, 1991) was in use at the feeder middle school. An explanation consistent with the data is that either *Visual Mathematics* or IMP was sufficient to enable high-ability students to do well on Test 3, with no value-added effect due to completion of both the visual mathematics and the IMP curricula. However, low-ability students did well only if they had utilized both *Visual Mathematics* and IMP. This explanation must be viewed as an hypothesis to be explored in a later study.

Schoenfeld (2002) noted that data analyzing the achievement effects of curricula designed to implement the *Curriculum and Evaluation Standards* (NCTM, 1989) are just beginning to become available. He stated that the data available so far seem to be converging on the following findings:

1. On tests of basic skills, there are no significant performance differences between students who learn from traditional or reform curricula.
2. On tests of conceptual understanding and problem solving, students who learn from reform curricula consistently out-perform students who learn from traditional curricula by a wide margin.

The results of the Algebra Achievement test were broadly consistent with the findings reported by Schoenfeld, and lend weight to this emerging trend. It should be noted, however, that in the investigation which most closely paralleled the current study, Huntley, et al. (2000) found that while students using a reform curriculum tended to out-perform students using a traditional curriculum on understanding and solving applied algebra problems in context and on solving complex open-ended applied algebra problems, they tended to be less skilled at symbol manipulation without context or access to graphing calculators. In the current study, while the results were not statistically significant, students in the Reform cohorts did perform less well than students in the Traditional cohort on the test of symbol manipulation. A closer look at the specific questions comprising Test 2 indicated that at Suburban High School the advantage of the Traditional cohort on symbol manipulation appeared to be limited to performing well-practiced procedures on items presented in standard form. When items were presented in non-standard form, for example solving $\sqrt{9 + x^2} = 5$ for x , the advantage of being in the Traditional cohort disappeared.

The close look at specific items yielded one cautionary note to the generally positive results on the Algebra Achievement test for students in the Reform cohorts. Fluency in procedures such as translating a line graph to an equation, where students in the

Traditional cohort showed more skill, could be important to student learning in later mathematics or science courses. The new *Principles and Standards for School Mathematics* (NCTM, 2000), published after a decade of debate and consensus building among educators, mathematicians, and parents that followed promulgation of the earlier *Curriculum and Evaluation Standards* (NCTM, 1989) placed increased emphasis on procedural fluency. Further, fluency may aid future learning because effortless processing places fewer demands on conscious attention. Since a person can attend to only a limited amount of information at one time, ease of processing some aspects of a learning task gives the person more capacity to attend to other aspects of the task (Bransford, Brown, & Cocking 1999).