Evidence of Student Success

During the Pilot Years from 1993-1996, the SIMMS Project rigorously evaluated student performance at each of the four main curriculum levels. Near the end of each year, students were tested using a traditional mathematics instrument (one of four PSAT tests) and a non-traditional problem-solving instrument. At each of the four levels, *SIMMS IM* students performed statistically as well as their non-SIMMS counterparts on the PSAT component and better overall on the problem-solving component.

These results on the traditional instrument of mathematical skills demonstrate that the *SIMMS IM* students did know the traditional mathematics skills at least as well as their counterparts in more traditional classes. *SIMMS IM* students learned the skills by applying them in problem-solving situations rather than simply doing drill problems. They also achieved the results on the PSAT when not allowed to use calculators even though technology use was an integral part of their everyday learning.

The results on the problem-solving instrument are especially significant because the *SIMMS IM* students outperformed their counterparts, often at statistically significant levels. Problem solving is a major goal of the curriculum with expectations that students will know the mathematical skills *and* be able to effectively apply them. These assessments validated that achievement.

The project studies were typically conducted as a one-year snapshot during the Pilot Years and often included different students each year. A more inclusive picture of the impact of the full *SIMMS IM* curriculum was illustrated in a four-year longitudinal study conducted in a single Montana high school. A summary of that study is included below. The bibliography following the summary includes the citations this study and all the studies conducted during the Pilot Years of the SIMMS Project.

Four-Year Longitudinal Montana School Study

A four-year longitudinal study was conducted over the academic years 1995/1996 to 1999/2000 (Souhrada, 2001). In the fall of 1995 the school chose to test the *SIMMS IM* (Reform curriculum as referred to in the study) curriculum against their traditional Algebra I, Geometry, Algebra II, Pre-calculus sequence. Parents were given information comparing the two and allowed to enroll their freshmen students in either program. Over the course of the four-year study, students progressed through the two curricula. During that time a third group of students emerged. These were students who took a mix of *SIMMS IM* (Reform) courses during some years and the traditional courses in the others for various reasons. This allowed for the comparison of three groups of students within the study; the *SIMMS IM* students, the Traditional students, and the Mixed students.

Within the *SIMMS IM* (Reform) curriculum the teaching and evaluation methods used were those prescribed by NCTM's *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), *Professional Standards for Teaching School Mathematics* (NCTM, 1991) and *Assessment Standards for School Mathematics* (NCTM, 1995) to make the most effective use from the program.

As such, students were typically arranged in groups of four, each group having computer access and all students having graphing calculators with computer algebra system (CAS) capability. The intention was for students to investigate mathematical concepts through the everyday use of technologies such as spreadsheets, statistical analysis programs, dynamic geometry software, computer- and calculator-based CAS, and graphing calculators.

In addition to students having a different setting and a variety of tools to use, the *SIMMS IM* materials made extensive use of cooperative learning, hands-on activities and explorations, student construction of mathematical concepts, and technology. Additionally, the mathematical concepts were presented and practiced in real world contexts in an effort to develop deeper understanding and problem solving ability. The mathematics content was integrated with other subject areas, as well as mathematics itself. This meant the *SIMMS IM* curriculum no longer followed the traditional Algebra I, Geometry, Algebra II, Pre-calculus sequence. The mathematical content was explored when the context made it necessary. For example, it is possible that students would be studying concepts in algebra, geometry, and probability in one unit. These ideals were also prescribed in NCTM's standards.

The students who were included in the study were only those who had taken the Comprehensive Test of Basic Skills (CTBS) during their eighth grade year in this district's middle school and completed all four years of high school in this same district. A total of 66 students (27 females and 39 males) were included with 17 *SIMMS IM* (Reform) students, 18 Traditional students, and 31 Mixed students. The CTBS results served as a baseline for where students began their high school careers mathematically. Using this measure there was no statistically significant difference in the three groups after completing their eighth-grade year. These three groups were also compared at the end of the four-year study based on their mean end of high school cumulative grade point average and their mean cumulative mathematics grade point average. Again, there was no statically significant difference between the means of the three groups.

This indicates that the three groups began on equal footing and according to grade point averages ended on equivalent footing. However, to allow traditional students to take AP Calculus as a senior, this district encouraged students to take two yearlong mathematics courses during their sophomore year. Of the 18 Traditional students, 9 (50%) took five (5) years of mathematics culminating in AP Calculus.

This phenomenon also appeared in the Mixed group. During the course of their high school career, some from this group chose to take a traditional course and a *SIMMS IM* (Reform) course in the same school year. Nine (9) of the 31 Mixed group students (29%) completed two courses in the same year as well. The fact that these students took five courses during their four years while the others took only four was not considered when evaluating the results of this study.

In addition to the students included in the study having no statistically significant differences in mathematics ability to start the study, there were also no differences in the instructors teaching the various courses included in the study. Both the traditional courses and *SIMMS IM* (Reform) courses were taught by the same three faculty members over the course of the study.

To measure these students mathematical ability both from a skill perspective as well as a problem-solving one, each group was given two exams at the end of each academic year. For the skills portion, different versions of the Preliminary Scholastic Aptitude Test/ National Merit Scholarship Qualifying Test (PSAT) Form T exam were given each year. For the problem-solving portion, a non-traditional problem-solving exam, the End of Year Test (EOYT) was given. The EOYT was designed so that no group had an advantage based on the content and context of the problems being presented. This assessment was intended not only to measure mathematical knowledge, but also perseverance and strategical methods used when facing unknown or new mathematical situations.

When the results of these PSAT exams were compared there was no statistically significant difference in the mean scores of the three groups in any of the four years. This was interpreted to mean that all three student groups were statistically equal in their procedural skill level. Again, this ignored the fact that several students from the non- *SIMMS IM* (Reform) groups had completed five years of mathematical content and that the *SIMMS IM* (Reform) students were not allowed to use technology which they had access to in all of their mathematics classes.

The results on the EOYT problem-solving exam showed no statistical difference between the *SIMMS IM* (Reform) students and the other two groups over the first three years. However by the end of the fourth year the *SIMMS IM* (Reform) students' mean score was significantly higher than that of the traditional group. It should also be noted that in each of the four years the Traditional students had the lowest mean score on the EOYT. This despite the fact that 50% of the traditional students had taken one more mathematics course by the end of their second year than any student in the *SIMMS IM* (Reform) group as well as 71% of the Mixed group.

For the complete study see the citation contained in the bibliography below.

Bibliography for the SIMMS Integrated Mathematics Project

This set of references includes the complete study cited above as well as documents that serve as resources for those wanting to find more detailed information about the philosophy, history, and support of the *SIMMS IM* curriculum.

Also included in this bibliography is the original citation for the *SIMMS IM* curricular materials. It should also be noted that in Spring 2019 the Montana Council of Teachers of Mathematics (MCTM) made the *SIMMS IM* curricular materials (including both Student Edition and Teacher Edition) available on line as open source materials for free usage.

The complete *SIMMS IM* curricular materials can be found at: www.mathmontana.org

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