RESEARCH SUPPORTING THE INTERACTIVE MATHEMATICS PROGRAM

The Interactive Mathematics Program (IMP) is the collaborative effort of mathematicians, teacher-educators, and teachers working together since 1989. Developed with support from the National Science Foundation (NSF)[1] and other funding agencies, the IMP first edition was published after more than 10 years of research, pilot testing, evaluating, field testing, revising, and detailed reviewing.

IMP is a comprehensive program of problem-based mathematics that integrates traditional material, such as algebra, geometry, and trigonometry, with coverage of important topics such as statistics and probability, which have been underemphasized in many traditional programs. The IMP four-year core curriculum meets college entrance requirements and prepares students to use problem-solving skills in higher education and on the job.

Research on Learning

The IMP authors drew on contemporary research about how students learn and developed a program that would offer students multiple ways to learn mathematics in a problem-solving context.[2] In the classroom, the teacher's goal is to challenge students to conjecture, to build arguments, and to formulate and solve problems. IMP students ask questions and learn key concepts and skills through an integrated and balanced treatment of all strands of mathematics.

> A salient feature of . . . NSF-funded curricula at every level is their emphasis on the sense-making activity of mathematics that requires reasoning and justification as part and parcel of understanding. . . . Moreover, the level of sophistication and degree of justification increases as students progress through the grades.[3]

Research on Program Effectiveness

Several long-term studies of student performance and participation show that the IMP curriculum improves students' learning and increases their study of advanced mathematics. Studies conducted during the pilot testing, a comprehensive NSF-funded evaluation during field testing, and further studies of the published curriculum yield several important conclusions.[4]

- On standardized tests, IMP students consistently perform as well as, and often better than, their peers enrolled in traditional high school mathematics course sequences.

[1] IMP materials development was sponsored by the National Science Foundation under award number EIS-9255262. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

[2] National Research Council. (2001). *Adding It Up: Helping Children Learn Mathematics*. J. Kilpatrick, J. Swafford, & B. Findell (Eds.). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

National Research Council. (2000). *How People Learn: Brain, Mind, Experience and School*. J. D. Bransford, A. L. Brown, & R. R. Cocking, Committee on Developments in the Science of Learning and Committee on Learning Research and Educational Practice, Commission on Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

Schoenfeld, A. H. When good teaching leads to bad results: the disasters of "well-taught" mathematics courses, *Educational Psychologist*, 23(2), 145–166.

[3] Robinson, E. & M., J. Maceli. (2000). The Impact of Standards-Based Instructional Materials in Mathematics in the Classroom. In M. Burke & F. Curcio (Eds.), *Learning Mathematics for a New Century* (2000 Yearbook of the National Council of Teachers of Mathematics, pp. 112–126). Reston, VA: National Council of Teachers of Mathematics.

[4] Schoen, H. (1993). Interactive Mathematics Program. In N. L. Webb, H. Schoen, & S. D. Whitehurst (Eds.), *Dissemination of nine pre-college mathematics instructional materials projects funded by the National Science Foundation*, 1981–91. Madison: University of Wisconsin–Madison, Wisconsin Center for Education Research.

Webb, N. L. (2003). The Impact of the Interactive Mathematics Program on Student Learning. In S. Senk & D. R. Thompson (Eds.), *Standards-Based School Mathematics Curricula: What are they? What do students learn?* (pp. 375–398). Mahwah, NJ: Lawrence Erlbaum Associates.

Wolff, E. (2001). Summary of Matched-Sample Analysis Comparing IMP and Traditional Students at Philadelphia High School for Girls on Mathematics Portion of Stanford-9 Test. In J. Merlino & E. Wolff, *Assessing the Costs/Benefits of an NSF "Standards-Based" Secondary Mathematics Curriculum on Student Achievement*. Philadelphia, PA: The Greater Philadelphia Secondary Mathematics Project.

- On tests focusing on quantitative reasoning, general problem solving, and statistics, IMP students significantly outperform their peers in traditional programs.
- IMP students demonstrate more positive attitudes about mathematics and take more mathematics courses, including advanced courses, compared to their peers in traditional programs.

[5] Webb, N. L., & M. Dowling (1996). Impact of the Interactive Mathematics Program on the retention of underrepresented students: Cross-school analysis of transcripts for the class of 1993 for three high schools. *Project Report 96-2.* Madison: University of Wisconsin–Madison, Wisconsin Center for Education Research (WCER).

[6] Ibid.

Closing the achievement gap

Data gathered from student subgroups show that IMP has a positive effect on student achievement among diverse student populations. In a transcript study of three high schools, IMP students were compared with their peers who took the traditional high-school mathematics course sequence. A statistically significant, higher percentage of IMP students completed at least three years of college-preparatory mathematics, and a statistically significant, higher percentage continued their studies in advanced courses in mathematics.[5]

This finding was true for all ethnic groups of significant size at each of the three schools in the study. (See Figure 1.) The finding was also true for both female and male students. Advanced courses undertaken by the IMP students included mathematical analysis, trigonometry and analytic geometry, precalculus, and calculus.[6]

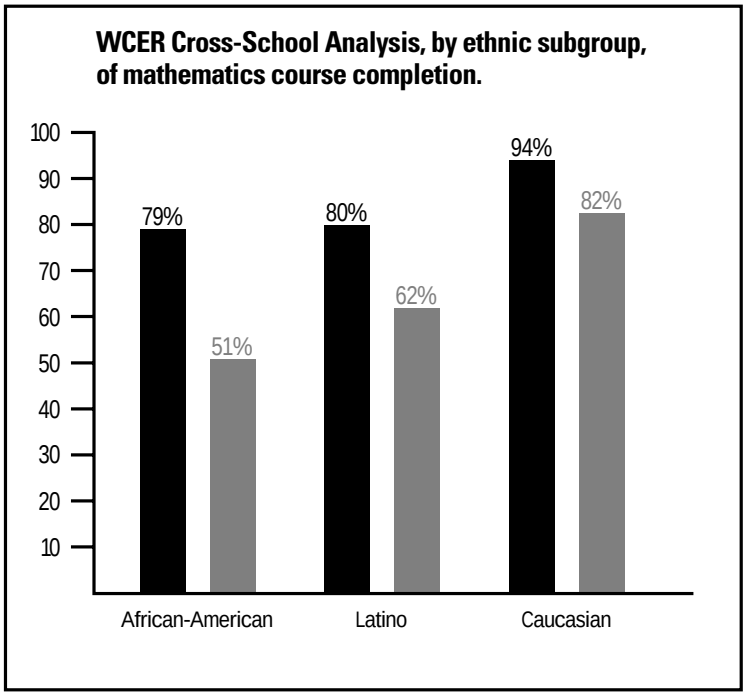

Figure 1

A statistically significant, higher percentage of IMP students completed at least three years of college-preparatory mathematics, as compared with their non-IMP peers. (Webb, 1996)

Key

Percentage of students completing at least three years of college-preparatory mathematics

IMP Students

Non IMP Students

A 1998 study analyzed standardized test scores among IMP students attending seven comprehensive high schools in Pennsylvania.[7] The African-American student population in these schools ranged from 52 to 98 percent of the total. The study examined the students' SAT 9 standardized test scores. To match student groups from IMP with non-IMP student groups, the analysis excluded some special categories of students. Scores for the IMP group exceeded those for the non-IMP group in every subscore, including reading and science. The Mathematics Performance Index for IMP student groups was 18.6 points higher than for non-IMP student groups.

[7] In J. Merlino & E. Wolff. (2001). *Assessing the Costs/Benefits of an NSF "Standards-Based" Secondary Mathematics Curriculum on Student Achievement.* Philadelphia, PA: The Greater Philadelphia Secondary Mathematics Project.

[8] Webb, p. 385.

[9] Merlino and Wolff, p. 24.

High-achieving student groups

Other studies show the IMP curriculum has positive effects for students who are identified as high achievers. At one school, where background data were available from seventh grade CTBS tests, students who scored in the upper quartile on these tests were identified as high performers.[8]

A separate analysis of these students yielded these results:

- IMP students achieved higher mathematics grade-point averages than non-IMP students.
- IMP students achieved higher overall grade-point averages than non-IMP students, even when accounting for mathematics grades.

Among the students in the analysis who chose to take the college aptitude SAT test, IMP students had a higher mean mathematics score than non-IMP students. Of students taking the test, the IMP group also had a higher percentage of students doing "very well" (600 or higher) than the non-IMP group.

In Philadelphia, Pennsylvania, the IMP curriculum was implemented in three special-admission schools—schools that draw students from the entire eighth-grade student population in Philadelphia and, consequently, accept applicants who are among the top-achieving student population. The 1998 study mentioned earlier analyzed standardized test scores of the IMP students at these three high schools. Scores for the IMP group exceeded those for the non-IMP group in every subscore on the SAT 9 standardized test, including reading and science. At these schools, the Mathematics Performance Index for the IMP student group was 7.8 points higher than for the non-IMP student group.[9]

Other indicators of student achievement

A carefully controlled, longitudinal study was conducted from 1996 to 2002 in a suburban United States high school that simultaneously adopted both the IMP curriculum and a "4 x 4 block" schedule. In a standard scheduling system, the day is typically divided into eight 45-minute classes that meet for a 180-day school year. In the

4 x 4 block schedule, courses meet for 90 school days for periods lasting an hour and a half. Although total class time is the same, the longer class periods provide the opportunity for students and teachers to work in greater depth on a subject.

One aspect of the study compared the Advanced Placement (AP) performance of IMP students using block scheduling to that of students in previous years who were using a traditional schedule and program. Students who used IMP in a block schedule showed these characteristics:

- A larger number of students enrolled in Calculus BC, the most advanced AP mathematics course.
- A larger number of students completed the AP Calculus BC exam.
- Scores on the AP Calculus BC exam were higher.[10]

[10] Kramer, S. L. (1997a, February and 1997b, March). What we know about block scheduling and its effects on math instruction, Parts 1 and 2. *Bulletin: National Association of Secondary School Principals,* 81, 586, 587.

Kramer, S. L. (2003). *The Joint Impact of Block Scheduling and a Standards-Based Curriculum on High School Algebra Achievement and Mathematics and Course Taking*. PhD diss., University of Maryland.

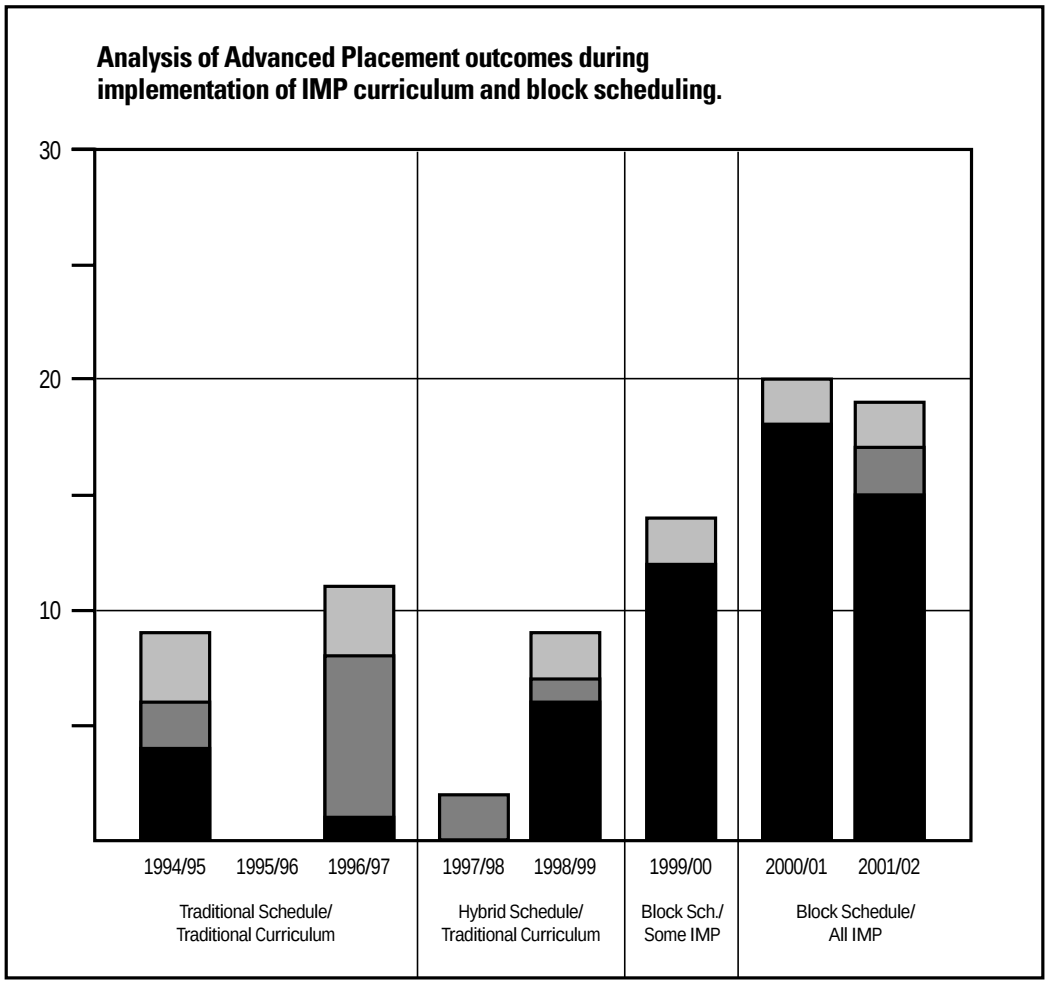

Figure 2

Block scheduling and the IMP curriculum were implemented over a three-year period. During that time, the number of students receiving the highest possible score of "5" on the BC Calculus exam increased. (Kramer, 2003)

Achievement beyond traditional content

Evidence that IMP students do as well as or better than non-IMP students on standardized tests is especially meaningful in view of the additional benefits provided by the program. During the four-year span of the IMP curriculum, students devote roughly 20 to 30 percent of their classroom time learning mathematical content, such as statistics, that is covered only briefly—or not at all—in traditional mathematics course sequences. They also learn communication and problem-solving skills that are crucial in the workplace.

Research has carefully documented the achievement of IMP students in these areas. For example, in a 1996 study using the five statistics items from the Second International Mathematics Study, grade nine IMP student groups achieved a mean score of 3.06 (out of 5) compared with a score of 1.02 for the non-IMP student groups. The two groups were matched on the basis of eighth-grade achievement tests; the difference in results is statistically significant at the .01 level. In parallel studies at the tenth and eleventh grade, IMP students as a group had scores that were higher, to a statistically significant degree, in the areas of quantitative reasoning and general problem solving.[11]

Changing attitudes toward mathematics

Other studies have examined attitudes of IMP students toward mathematics as a field of knowledge. Findings show that IMP students are more likely to value what they are learning and to perceive mathematics as being useful in their daily lives.[12]

Success in admission to college

Finally, one of the major criteria by which parents measure success is whether a program allows students to gain admission to colleges of their choice. The IMP curriculum is recognized as meeting college preparatory mathematics requirements. IMP students are routinely admitted to major state college and university systems, all the schools of the Ivy League, other nationally recognized schools such as Stanford and Wellesley, and historically Black colleges such as Howard and Spellman. A list of schools where IMP students have been accepted is available on the Web at www.mathimp.org. The Web site also contains extensive information about the IMP program.

[11] Webb, N. L. & Dowling, M. (1997). Comparison of IMP Students with Students Enrolled in Traditional Courses on Probability, Statistics, Problem Solving, and Reasoning. *Project Report 97-1*. Madison: University of Wisconsin–Madison, Wisconsin Center for Education Research.

[12] Clarke, D., et al. (1992). The Other Consequences of a Problem-Based Mathematics Curriculum, *Research Report No. 3*. Mathematics Teaching and Learning Centre, Australian Catholic University.

Boaler, J, et al. (2002). Choosing a math curriculum: Information from Greendale High School. Stanford, CA: Stanford University Teaching and Learning Center. Available: http://www.stanford.edu/~joboaler/curriculum/stanford.html.

