
Show-Me Project Brief

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Research on the Impact of Standards-Based Middle Grades Mathematics Curricular Materials on Student Learning

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Concerns about mathematics learning among American youth are widespread and based on evidence from a variety of national and international studies (Beaton et al., 1997; National Research Council, 1989, 1997, 1998). Most recently, results of the 1999 Third International Mathematics and Science Study (TIMSS-R) indicate that U.S. students “fall behind during the middle school years” (Schmidt, 2000, p. 1), a trend that continues through high school when, by graduation, American students perform almost last among secondary students tested in 41 nations (Glenn, 2000).

General dissatisfaction with student performance, particularly in the middle grades, stimulated calls for more rigorous and relevant mathematics curricular materials by professional organizations such as the National Council of Teachers of Mathematics (NCTM) and the American Association for the Advancement of Science (AAAS) (AAAS, 2000; NCTM, 1989, 2000). In response, the National Science Foundation sponsored curriculum development efforts to produce “standards-based” mathematics curricula that embody the major tenets of reform. At the middle school level, four comprehensive curriculum projects – *Connected Mathematics Project*, *Mathematics in Context*, *Mathscape*, and *MATH Thematics* – were developed to represent a significant departure from traditional textbook series in both content and pedagogical orientation. Each of these curricula is mathematically rigorous, comprehensive (multi-year core curriculum based on content in NCTM *Standards*); extensively field tested and revised based on pilot data; built on a sound instructional design (aligned with NCTM *Standards* expectations); used in the field (market acceptance); positively impacting student learning (confirmation by independent researchers); and published and distributed nationally by a commercial vendor. Moreover, these four middle school mathematics curricula received the highest quality ratings in the American Association for the Advancement of Science (AAAS, 2000) review among 13 middle school mathematics textbook series evaluated.

Research has long documented the profound influence the textbook has on the mathematics content that is taught and learned (Koebler & Grouws, 1992). Mathematical content not included in instructional materials is seldom taught by the teacher (Driscoll, 1981; Porter, 1989) and curricular materials often influence the pedagogical strategies used by teachers. At the middle school level, U.S. textbooks emphasize skills rather than problem solving (Epstein & Mac Iver, 1989; Flanders, 1987; Schmidt, McKnight, & Raizen, 1997), focus on topics normally addressed in earlier grades in other countries (Peak, 1996), and are largely review and redundant in mathematical content (Flanders, 1987; Porter, 1989).

Only recently, however, has research begun to document the impact of standards-based curricula on student learning. Much of the evidence regarding the impact on student learning of standards-based middle school mathematics curricula results from small scale investigations. These investigations include studies of small groups of students (Keiser, 1997; Krebs, 1999; Wasman, 2000) and studies involving groups of teachers and students piloting the materials (Ben-Chaim, Fey, Fitzgerald, Benedetto, & Miller, 1997; de Lange, Burrill, Romberg, & van Reeuwijk, 1993; Hoover, Zawojewski, & Ridgeway, 1997; Miller & Fey, 2000; Romberg & Pedro, 1996; Webb & Meyer, 2001). Most of these studies are short-term in scope (one year or less) and limited to the impact of one of the middle school mathematics curricula. Nevertheless, results from extensive field testing indicate middle school students experiencing standards-based curricula do as well as students from more traditional programs as measured by standardized tests of traditional content. Moreover, these students outperform comparison students on items measuring students’ reasoning, communication, and problem-solving abilities, and exhibit a positive attitude toward mathematics (Senk & Thompson, 2003).

This research has documented significantly higher levels of student learning, particularly in the higher cognitive demand areas such as problem solving compared with students using traditional materials (Reys et al., 2003). Additionally, students using standards-based curricula are more likely to look for and identify patterns and relationships. Students using standards-based curricula are reportedly more engaged in exploring mathematics, and are better able to explain and record their mathematical thinking (Wasman, 2000).

Although there have been short-term, small-scale research investigations, a need exists for research studies to document the impact of standards-based mathematics curricula on student learning over an extended period of time. Researching of the impact of standards-based mathematics curricula on student achievement is complex (Sawada et al., 2002) and difficult to conduct for many reasons including gaining access to schools, documenting the fidelity of implementation, the necessity of collecting data over a sustained period of time, identifying appropriate comparison groups, and accessing valid measures of student achievement (Hiebert, 1999; Schoenfeld, 2000; Usiskin, 1998). Additionally, variables other than textbook use contribute to student learning, including quality of teaching and parental support. Notwithstanding these challenges, several recently published studies provide additional evidence of the impact of standards-based curriculum on student achievement.

Riordan & Noyce (2001) compared scores on the state-mandated assessment of mathematics of students from two groups of schools. One group included students from every school in Massachusetts that had used a standards-based curriculum in the 4th or 8th grade for at least two years. The other group included students from Massachusetts schools carefully selected to match the first group on two important predictors of achievement – prior achievement and socioeconomic status. Results indicated that students using standards-based curriculum materials as their primary text performed significantly better on the state-mandated mathematics assessment than did students in schools using traditional textbooks. The differences were consistent across various content strands, assessment problem types, and student sub-populations. Additionally, in schools that had used the materials for longer periods of time (at least 4 years) gains were more dramatic. These results are consistent with other studies showing standards-based curricula benefit students of varying abilities, including those at the higher and lower achieving levels (Briars, 2001; Griffin, Evans, Timms & Trowell, 2000).

Reys et al. (2003) compared the mathematics achievement of more than 2000 eighth grade students from six different school districts in the state of Missouri. Three of these districts were chosen due to their status as the first in the state to adopt NSF-funded standards-based middle grades mathematics curricula; the remaining three were chosen for their representation of districts with similar prior mathematics achievement and family income level as in the standards-based districts. Achievement was measured using the mathematics portion of the Missouri Assessment Program (MAP), a state-mandated exam administered annually to all Missouri eighth graders to assess students' mathematical skills, concepts, and problem solving abilities as noted in the Framework for Curriculum Development in Mathematics, K-12. It was determined that students who had used standards-based materials for at least two years scored significantly higher than students from the districts that used non-NSF curricular materials. Specifically, students from each of the three districts that used standards-based materials scored significantly higher in the areas of data analysis and algebra.

The TIMSS-Repeat study conducted in 1999 offers additional evidence of the impact of standards-based mathematics curriculum materials on student achievement. Two groups of students from Michigan participated in TIMSS-R. The first group was a set of randomly selected schools that served as the state sample. The second group was an "invitational" group of schools who met certain criteria including use of standards-based instructional materials, a well-articulated district curriculum, use of assessment data to inform instructional decisions, professional development to support teachers and good communication with the community. This group consisted of 21 schools representing rural, suburban and urban environments. The Michigan state sample was the highest performing state group among the 12 states participating in TIMSS-R (score of 517). The Michigan invitational group performed significantly higher than the Michigan state sample (score of 532), indicating the positive effect of standards-based reform efforts within these schools (Mullis et al., 2001).

In summary, the available research indicates that the impact of standards-based middle school mathematics curricula is generally positive. Specifically, the data indicate:

- Students using standards-based curricular materials demonstrate higher achievement levels in mathematics than students using traditional materials and these differences are consistent across various content strands, assessment instruments, and student sub-populations.
- Students using standards-based curricula are more likely to look for and identify patterns and relationships, are more engaged in exploring mathematics, and are better able to explain and record their mathematical thinking.

In addition to the positive impact on student learning, research documents that implementation of standards-based curricula provides opportunities for professional growth of teachers. However, realization of this professional growth depends on several factors including teachers' willingness to consider new instructional approaches and the quality and level of organized and sustained activities to support teachers' use of new curricular materials (Ball, 1996; Reys & Reys, 1997). Where implementation of standards-based curricula coincides with a strong professional development plan, teachers' knowledge of content grows, pedagogical approaches expand, expectations of students increase, and confidence and success in using standards-based curricula grow (Preston & Lambdin, 1997; Senk & Thompson, 2003). Moreover, implementing standards-based curricula contributes to teachers' own depth of knowledge of middle school mathematics (Lambdin & Preston, 1995; Stevens, 2001; Tetley, 1998; Van Boening, 1999). Notwithstanding these benefits, teachers clearly differ in their ability and willingness to adjust to a student-centered instructional environment (Silver, Smith & Nelson, 1995). Available evidence suggests that significant change in how teachers teach mathematics can occur with strong administrative support and an intense and sustained program of professional development focused on curriculum, mathematics content and pedagogical issues (Bay, Reys & Reys, 1999; Ferrini-Mundy & Johnson, 1997; Lappan, 1997).

The documentation of the impact of standards-based curricular materials on student achievement is a recent endeavor. Additional research is clearly needed to ascertain the long-term impact of curricular materials on student learning. To this end, several recently funded projects have begun to examine the extent and nature of implementation of standards-based curricular materials on student achievement in middle grades mathematics. Among these, the United States Department of Education has sponsored the *Middle School Mathematics Study* at the University of Missouri to explore the relationship between student learning and fidelity of implementation of standards-based curricula, and to compare achievement among students experiencing standards-based curricula to those from traditional programs. With support from the Interagency Education Research Initiative (IERI), *Project 2061* – in partnership with the University of Delaware and Texas A & M University – is documenting factors that improve student learning in mathematics including the professional development of teachers. An NSF-funded longitudinal, cross-sectional study at the University of Wisconsin has been undertaken to ascertain the impact of *Mathematics in Context* on student mathematical achievement and to compare the performance of students using *MiC* with that of students using conventional middle school mathematics programs (Romberg & Shafer, 2003). Collectively these research projects should yield further insight into the impact of standards-based curricular materials on student learning in mathematics.

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