Chapter 1

The Implementation and Impact of Mathematics Reforms in High-Poverty Middle Schools

Robert Balfanz, Douglas J. Mac Iver, and Vaughan Byrnes
Johns Hopkins University

We begin this chapter by taking our readers back to the early 2000s. At that time, we noted in our *Journal for Research in Mathematics Education* (*JRME*) article that "middle school mathematics in the United States is in need of reform" (Balfanz, Mac Iver, & Byrnes, 2006, p. 33). We stated that middle school students learned less mathematics than their peers in many other countries (e.g., National Center for Education Statistics, 2000; Schmidt, McKnight, Cogan, Jakwerth, & Houang, 1999) and that the opportunity to acquire a substantial body of mathematical knowledge during middle school was unevenly distributed across the country (e.g., Balfanz, McParland, & Shaw, 2002; Campbell & Silver, 2000). In particular, high-poverty urban middle schools, attended predominately by minority students, appeared to provide fewer of the supports and resources that students need in order to learn a significant amount of mathematics during middle school. Recognition of the increased significance of middle school mathematics led to multiple reform proposals and the consensus that such reform should include several core elements:

- Students need to be provided with a coherent curriculum that is less cursory and repetitive and that systematically develops their intermediate mathematics skills and their mathematical reasoning ability.
- Middle school mathematics teachers, in order to implement a more challenging and comprehensive curriculum, need access to sustained high-quality professional development that is linked to the instructional materials they will be using; that focuses on their classroom activities; and that provides them with the content knowledge, pedagogy, and classroom management skills needed to implement a challenging middle-grades mathematics curriculum.
- Mathematics reforms need to be embedded in state, district, and whole-school reforms that facilitate instructional program coherence by aligning accountability, assessment, and resources; that create teaching and learning environments cognizant of the developmental transitions that occur in the middle grades; and that promote an "Every Child Can Succeed" culture in which students, teachers, and parents do what it takes to provide the supports needed for all students to receive a strong mathematical foundation.

At that time there was evidence that each of these reforms practices altered instructional practice and/or student effort in a productive manner and consequently raised mathematical achievement. However, as we planned our project we found that there had been little research in high-poverty schools, particularly at the middle school level, on the cumulative impact on this set of evidence-based practices, especially across multiple schools and over multiple years. We needed to know more than simply which reform strategies appear to

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This chapter is adapted from R. Balfanz, D. J. Mac Iver, & V. Byrnes (2006), The implementation and impact of evidence-based mathematics reforms in high-poverty middle schools: A multi-site, multi-year study, *Journal for Research in Mathematics Education*, *37*, 33–64.

raise average state or district levels of achievement; we needed to know the levels of impact these sets of strategies have under different conditions—in particular, (1) the extent to which the combined set of evidence-based mathematics education reforms outlined above can be implemented and sustained in high-poverty middle schools, (2) the level of implementation support needed to overcome existing conditions, (3) the level of impact on achievement that can be expected under different conditions, and (4) if the emerging set of evidence-based reforms in and of itself is sufficient to have a significant impact on improving mathematical achievement.

In our *JRME* article (Balfanz et al., 2006) we reported on results from the first four years of an ongoing effort to develop and implement a comprehensive and sustainable set of evidence-based curricular, professional development, and supportive whole-school reforms aimed at raising mathematical achievement in high-poverty middle schools. In this chapter, we summarize the content of the article; we refer our readers to the article for more complete information. The first section of the chapter provides information on the schools that participated in the study; the second section focuses on factors such as the levels of implementation achieved and the impact of the reforms on multiple measures of mathematics achievement; and the third section contains a discussion of the overall impact of the reforms and explores additional steps needed to achieve high levels of mathematical learning in high-poverty middle schools. Where relevant we include page number references to the *JRME* article that lead the reader to information not included in the chapter.

Designing the Mathematics Reforms and the Context of Our Study

At the start of the project in 1996, one of the authors spent a year observing mathematics instruction and the mathematics program in twelve classrooms within two of the three middle schools that would ultimately participate in the project. The schools were in the School District of Philadelphia and were nonselective neighborhood schools serving low-income minority populations. The observations revealed that these high-poverty schools shared many of the weaknesses reported in the literature about middle school mathematics in general (Balfanz, 1997). For example, the observed mathematics instruction was disorganized and idiosyncratic. Across and within grades, teachers were using different mathematics curricula, partly because of textbook shortages and partly as a reflection of teacher taste. Essentially, each teacher was making individual decisions about the type and level of mathematics needed by his or her classes. One unintended result of this individual decision making was a highly repetitive course of study across the grades, in which less and less grade-level material was introduced each year. For example, during one class day in September, students at all four grade levels (5–8) were learning about place value.

In the case of the teachers, most were unenthusiastic about teaching mathematics but had been assigned to do so, usually in combination with one or two other subjects. With one exception, all of the teachers were elementary certified. Many viewed teaching mathematics as a short-term assignment—a chore they would do until they obtained a better assignment within or outside of the school. There was a high degree of turnover in who taught mathematics and at what grade level.

The overwhelming majority of students in both schools entered the middle grades significantly behind grade level in their mathematics skills and knowledge as measured by scores on the Stanford 9 test. Moreover, because both schools served neighborhoods with high concentrations of poverty (in both schools, more than 80 percent of students were eligible for free or reduced-price lunches), the students brought with them greater levels of exposure to safety risks, unhealthy environments, and high levels of social disorder.

The two schools we observed had unsupported and essentially temporary mathematics teachers using an unorganized curriculum. These teachers faced the difficult task of enabling their students both to master the middle-grades curriculum and to close their elementary skill and knowledge gaps in the context of the myriad challenges endemic to high-poverty schools. This year of observation made it clear to us that, in order to succeed, any attempt to improve mathematics achievement would need curricular, professional development and teacher-support elements, and it would need to take place in the context of schoolwide reform. Based on our observations and an extensive literature review, we formulated a program—the Talent Development (TD) Middle School Mathematics Program—that we describe next.

The TD Middle School Mathematics Program

The TD Mathematics Program was a core component of a larger, whole-school reform design (the Talent Development Middle School) that integrates organizational, curricular, professional-development, school-climate, teacher-student interaction, and student-support reforms into a comprehensive set of reforms for high-poverty middle schools (see Mac Iver, Ruby, Balfanz, & Byrnes, 2003, for more information). The sections that follow briefly describe the essential features of the TD Mathematics Program.

Schoolwide use of coherent and challenging curriculum

To resolve the issue of individually selected mathematics materials, the schools implemented *Everyday Mathematics*, from the University of Chicago School Mathematics Project (UCSMP) elementary curriculum, for grades 5 and 6; in grade 7, UCSMP *Transition Mathematics* was used; and in grade 8, UCSMP *Algebra* was used. These materials were developed on the premise that students should be taught a substantial body of challenging mathematics and that algebra and geometry should be introduced early on and with greater emphasis (UCSMP, 2003). The curriculum also had a strong focus on mathematical reasoning, problem solving, and communication. The UCSMP curriculum received a promising program endorsement from the U.S. Department of Education's Mathematics and Science Expert Panel (1999).

One of the three middle schools participating in the project was attempting to teach all students algebra in eighth grade, so in this school UCSMP *Algebra* was adopted schoolwide during year 1 of implementation of the TD Mathematics Program. The other two schools phased in the *Algebra* text over a three-year period in order to allow time to build both teacher skills and student skills. In these two schools, seventh and eighth graders used *Transition Mathematics* during year 1. During year 2, eighth graders used lessons from *Transition Mathematics* and the *Algebra* text. In year 3, the *Algebra* text was used from the start of eighth grade. All three schools introduced *Everyday Mathematics Grade 5* (in the two grade 5–8 schools) and *Everyday Mathematics Grade 6* in year 1 of program implementation. Thus, by the start of year 3, all three schools were offering all students the same mathematics curriculum and sequence of courses, culminating with all students taking an algebra course in eighth grade.

Multiple tiers of sustained professional development

Teachers in the three schools were offered tiers of professional development linked to the implementation of the new mathematics curriculum. Three days of summer training were followed by monthly three-hour Saturday workshops, with make-up sessions available. Experienced peer teachers and users of the curricula led the workshops. The sessions were grade specific and focused on the unit or lessons the teachers would be using during the following month. (For an example of a professional development session on geometry, we refer the reader to pp. 38–39 of the 2006 *JRME* article.) In all, teachers had access to more than thirty-six hours of professional development per year. Attendance was voluntary, and teachers were paid the district rate (approximately $20 per hour at that time). Beginning in year 2, arrangements were made at a local university to give teachers three graduate credits if they completed thirty-six hours of training and related assignments. The goal here was to provide teachers with more professional development opportunities than had been typically available to U.S. mathematics teachers at that time.

In addition to the professional development sessions, teachers had access to support from a curriculum coach, who spent one or two days per week in each school. The curriculum coach was an experienced district teacher on special assignment to the project. The support was designed to be nonjudgmental, and it varied from classroom to classroom but included modeling, explaining, co-teaching, lesson planning assistance, observing lessons and providing confidential feedback, and making sure teachers had necessary materials for the lessons. During year 3 of the program, we began an initiative to train two to three teacher leaders from each school to be on-site trainers, with the goal of making the schools self-sustaining over time. These teacher leaders received an additional thirty hours of training per year for two years and provided an additional layer of support in the schools.

Teacher participation in program improvement

Each summer, the teachers were invited to take part in working groups to develop supplemental materials to help further customize and localize the instructional materials. The activities varied over the course of the project. For example, during the third summer, September Introductory Units were developed. These units were designed to compensate for the "broken supply lines" found in many urban schools at the start of the school year. At times schools fail to provide teachers with essential supplies and learning materials in a timely fashion. The September Introductory Units made it possible for teachers to begin teaching substantive standards-based lessons right away even if the regular materials their schools were supposed to supply had yet to be ordered, found, or delivered into their hands.

Embedded in whole-school reform

The three schools not only enacted the mathematics education reforms outlined above in the context of implementing the TD model but also adopted schoolwide reforms. The schools were also engaged in reforms in English and science that employed similar approaches to professional development as those outlined for mathematics. In addition, the schools made organizational changes to increase the communal nature of the schooling, including looping (where teachers stay with the same class of students for two years), semi-departmentalizing (teachers taught two subjects to the same class, so they only interacted with sixty to seventy students during a school year), and dividing the school into small learning communities (SLCs). Both survey data and interviews indicated that these reforms led to a greater sense among students that "my teacher cares about me," enabled teachers to adopt riskier but more engaging pedagogy, and helped form a "no excuses" attitude toward student success (e.g., see Mac Iver, Mac Iver, Balfanz, Plank, & Ruby, 2000).

Summary

The TD Mathematics Program was designed to encompass the (at that time) emerging set of evidence-based reforms in mathematics education. It had a high level of instructional program coherence and a challenging mathematics curriculum that culminated with algebra for all in grade 8. In addition, the program provided much more intensive, focused, and sustained professional development than teachers at that time were typically given, was integrated into a set of whole-school reforms, and was accompanied by substantial implementation support.

Program of Research

In any reform effort done at that time (and perhaps even now, about fifteen years later), the questions inevitably arise as to whether the program "worked." To answer this kind of broad question about the TD Mathematics Program, we worked with the School District of Philadelphia, which selected three comparison schools for each participating school that was similar in racial composition, high-poverty status, and past performance during the period before TD began in the district. The characteristics of the three TD schools and the three comparison schools appear in table 1.1.

Table 1.1
Characteristics of participating schools (TD) and comparison schools: Grade span, eighth-grade enrollment, race, and math test scores for school years 1995–1996 through 1996–1997

School	Grade span	Eighth graders enrolled	Black %	White %	Other %	PSSA math score (NCE)	Stanford 9 math total (NCE)
TD A	5–8	258	26.2	12.9	60.9	27.3	35.5
Comparison A	5–8	296	18.9	20.1	61.0	24.1	33.2
TD B	5–8	264	74.8	1.0	24.3	24.9	34.8
Comparison B	5–8	201	65.1	11.2	23.7	27.7	36.2
TD C	6–8	399	98.3	1.2	0.5	30.0	41.1
Comparison C	6–8	210	99.6	0.0	0.4	27.2	38.9

Note: Race and test scores are averages for eighth graders from individual student school records. Thanks to James Kemple and Corinne Herlihy for performing the calculations reported in this table.

Another comparison characteristic important to our research studies was that more than 70 percent of the students in both the TD schools and the comparison schools entered middle school performing below grade level in mathematics; the range was 71 percent to 86 percent. (More complete information about the TD schools, the comparison schools, and their school district can be found on pp. 41–44 in the 2006 *JRME* article.)

We developed an interrelated set of questions about the implementation and impact of the TD mathematics program:

1. How successfully were the intended reforms implemented and sustained in the schools?

2. Did the students who attended the experimental schools have greater achievement gains than students who attended the matched control schools on the high-stakes district assessments and on the lower-stakes state assessments?

3. What was the relationship between implementation levels and achievement gains?

The results are reported in abbreviated form in the next sections. We invite our readers to consult the original *JRME* article and other relevant publications (a list appears as an appendix to this chapter) for a more comprehensive presentation of the statistical models and the findings. In this section of the chapter our primary focus is on the conclusions that we drew from the analyses.

Implementation levels

Multiple methodologies (e.g., student surveys, a curriculum coach's evaluation of classroom activities, teacher focus groups, individual interviews of teachers) were used to analyze the implementation levels of TD and the roadblocks that teachers encountered. Overall, the implementation measures indicated that a moderate-high level of implementation was achieved across the three schools. This implies that despite endemic problems, such as high staff turnover, it is possible to obtain an acceptable level of reform program implementation in high-poverty middle schools.

The sections that follow detail the implementation levels across the schools primarily in the fourth year of the project. This year is highlighted because it represents the most mature year of the project and it is the year for which the largest body of implementation data was available.

Interviews and focus groups

Interviews and focus group results showed that, in general, teachers liked the TD curriculum being implemented, felt that they were receiving good quality professional development, and recognized that the in-classroom implementation was both beneficial and much more intense than teachers commonly received. (See Useem, 1998, 1999, 2000, 2003).

Participation in professional development

Nearly 80 percent of the teachers attended some professional development sessions (participation was voluntary per the local union contract), and about two-thirds achieved the recommended level of thirty-six hours per year for two years. Thus, the majority of TD teachers had achieved a satisfactory level of training in regard to the program's specific curriculum and pedagogy, although a significant portion still lacked adequate training.

Teacher experience and stability

One of our biggest implementation challenges was a high degree of teacher turnover. This meant that each year many of the well-trained teachers left and were replaced by new, untrained teachers. By the fourth year of the study, only 31 percent to 59 percent of the classrooms in the three schools had mathematics from a teacher who had participated in the TD project all four years.

Recommended instructional practices

The survey results from the fourth year of implementation indicated that 71 percent of the classrooms across the three TD schools used five or more of the nine recommended instructional practices (e.g., students explaining how they got their answers; students working with a partner; whole-class work on a challenging problem) versus 51 percent of the classrooms in the control schools.

Curriculum coverage and implementation roadblocks

The initial goal of having TD teachers complete six to eight units of each grade level's instructional materials was by and large *not* achieved. Factors such as pressure to use district test preparation materials, numerous scheduling disruptions, and the wide range of student skills in the heterogeneous classrooms contributed to this situation. The average classroom completed four and a half units from the UCSMP instructional materials.

The curriculum coaches in each school were asked to identify the number and type of roadblocks teachers encountered. Almost all of the identified roadblocks were the result of staff turnover, lack of training, teaching inexperience, and/or poor classroom management. Only one of the three schools identified lack of materials as a major roadblock.

Impact on growth in mathematics problem solving

Extensive achievement data were available from the three TD schools and their three comparison schools across all four years of the study. Most cohorts in these schools took the mathematics problem-solving battery of the Stanford 9 test two or three times during their middle school years. In our preliminary analyses, we found no significant differences between the groups (TD and control) in prior achievement. We used hierarchical linear modeling (HLM) methods to model the achievement of all students who attended one of the six schools at any time between the fall of 1997 and the spring of 2001 *and* took the Stanford 9 at least once during their time of attendance.

The results showed that the TD schools raised their school mean achievement growth in problem solving substantially more than did the comparison schools. The model estimates also revealed a slight decline in the TD advantage over the comparison schools from seventh grade to eighth grade, which may be explained by the shift of the TD eighth-grade curriculum to algebra.

The TD Mathematics Program focused on improving students' mathematical problem-solving skills as opposed to routine mathematics procedures. As a result, we expected TD students to do no better (and no worse) than control students on the Stanford 9's Math Procedures Subtest. As expected, when analyses were conducted on students' growth in procedures scores there were no significant differences between students in the TD schools and in the control schools.

Impact on mathematics achievement growth between fifth and eighth grade on state assessments

To further understand and analyze any achievement benefit incurred by students in the TD Mathematics Program, we examined the extent to which students in both the TD schools and the control schools experienced achievement gains between the end of fifth grade and the end of eighth grade on the Pennsylvania System of State Assessments (PSSA) in mathematics, the state-required exam at that time. The PSSA was viewed as a lower-stakes test than the Stanford 9. Again, we used HLM to analyze the data for this part of the study.

Results showed that TD schools increased their school average scores and the degree to which they met concrete district or state-determined benchmarks. In Pennsylvania at the time of the study, students who scored below the 25th state percentile were considered "below basic." Our findings showed that in the TD schools there was a 10 percent increase in the percentage of students scoring above this critical 25th percentile between the fifth and eighth grades, whereas the control schools had only a 2 percent gain. Thus, although both the TD schools and the control schools had similar percentages of students with below basic skills in the fifth grade (26 percent vs. 23 percent), by the eighth grade more than one-third of the students in the TD schools had crossed this significant threshold, compared to only one-fourth of the control school students. We also found that the TD schools outperformed the control schools in raising the percentage of students scoring above the 10th and 50th percentiles. These results along with others reported in the article (see tables 12 and 13 in Balfanz et al., 2006, p. 55) indicate that the set of evidenced-based mathematics reforms implemented in the TD schools helped students at all levels of the achievement spectrum in educationally significant ways.

Achievement outcomes and implementation levels

Thus far we have reported that students in the TD schools achieved more than their peers in control schools. This final analysis tied the achievement outcomes to variation in implementation and showed that *greater implementation of the reform model produced better outcomes*. For this analysis we used the implementation data for the fourth year of implementation (2000–2001), and we estimated the relationship between different implementation levels and students' achievement in spring 2001 after controlling in the statistical model for prior achievement in spring 2000. An HLM model was used, and details about the model and statistical information can be found on pages 54 and 56–57 of the 2006 *JRME* article. Within the TD schools, the classrooms with higher levels of program implementation averaged higher achievement gains, and we suggest that even larger gains could have been made if more of the implementation roadblocks had been removed.

Conclusion

Here, we highlight three important findings that were reported in the article. First, it is possible to implement and sustain a comprehensive set of mathematics reforms that incorporate evidence-based curriculum, professional development, and whole-school reform practices in high-poverty middle schools. Across the four years of the study, two-thirds to three-fourths of classrooms in the three middle schools obtained at least a medium level of implementation. The support infrastructure put in place (in-class coaching, ongoing professional development, nesting within whole-school reform) was strong enough to withstand the high rates of principal and teacher turnover, shifting district foci, significant rates of student mobility, and dysfunctional responses to scarcity and uncertainty that were (and still probably are) emblematic of high-poverty middle schools.

Second, implementation of the comprehensive set of mathematics reforms led to significant and substantial achievement gains across multiple classrooms in multiple schools over multiple years. Those gains occurred across all levels of the achievement spectrum. All types of students benefited from a richer and more demanding curriculum, better trained and better supported teachers, and an improved teaching and learning environment. Comparing the magnitude of the impact of the TD mathematics reforms on student achievement to prior results for its individual components suggests that benefits were gained by combining evidence-based curricular, professional development, and whole-school reform practices into a coherent and integrated reform effort that was sustained for four years. The strength of our results in the face of challenging implementation conditions (i.e., the roadblocks we mentioned earlier in the chapter) further suggests that a package of evidence-based mathematics reforms should become a standard feature of high-poverty middle schools and perhaps all middle schools with significant achievement gaps. Such reforms include coherent and challenging instructional materials used schoolwide, grade- and curriculum-specific ongoing professional development, in-class coaching, and whole-school restructuring to create improved teaching and learning climates.

Third, although achievement results were statistically significant and educationally substantial, they were not of sufficient magnitude to allow us to conclude that the enacted reforms alone were enough to close all the achievement gaps that high-poverty students bring to urban middle schools. A more detailed analysis (see Balfanz & Byrnes, 2006) revealed that a near majority of students in the TD schools were able to substantially close their achievement gaps, learning on average more than a year's worth of mathematics per year while in middle school. The remaining students, however, did no better than tread water, with their achievement gap remaining constant during the middle grades. This clearly indicates that additional reforms and supports will be needed to provide all middle school students with the mathematics skills and strategies they need to succeed in a rigorous set of high school mathematics courses.

We concluded the article by stating that the results of our study were encouraging. They show that the emerging set of evidence-based reforms in mathematics curriculum, professional development and teacher support, and whole-school reform, when integrated, can significantly raise mathematics achievement in high-poverty middle-grades schools. At the same time, they also show that much work remains to be done before we can reliably provide all middle schools with the tools, technologies, and human resources they need to both effectively teach standards-based mathematics and close the skill and knowledge gaps of all their students.

Suggestions for Practitioner Use of Our Work

We close with a suggestion about how our practitioner readers could use the information about and results from the TD Mathematics Project. It has been almost ten years since the *JRME* article was published, and during that time we have published other articles and books about the project. A list of these publications appears in the appendix. For mathematics educators who with their preservice or in-service teachers are looking carefully at the reform movement in mathematics education, we offer the list as a way to obtain information about one reform effort. The contents of the articles and other publications can foster a discussion of the project in light of recent standards movements such as the Common Core State Standards for Mathematics (National Governors Association Center for Best Practices & Council of Chief State Officers [NGA Center & CCSO], 2010).

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Appendix

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