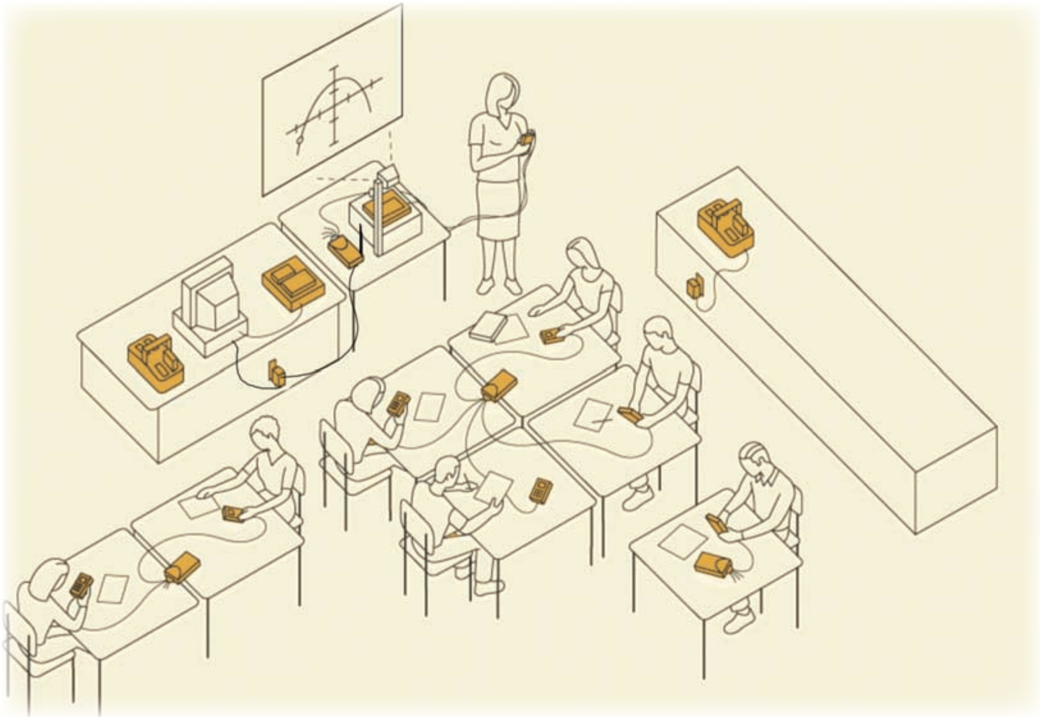
MathForward™
Implementation Quality Report



August 2008

SRI International
Center for Technology in Learning
333 Ravenswood Avenue
Menlo Park, CA 94025-3493
650.859.2000
www.sri.com

MathForward™ Implementation Quality Report

Prepared for:
Dr. Rob Foshay
Texas Instruments

Prepared by:
William R. Penuel
Kate Ferguson
Corinne Singleton
Sheila Shea
Kate Borelli
Christine Korbak
SRI International

August 2008

SRI Project P17094

SRI International
Center for Technology in Learning
333 Ravenswood Avenue
Menlo Park, CA 94025-3493
650.859.2000
www.sri.com

EXECUTIVE SUMMARY

The Texas Instruments (TI) MathForward™ program is a systemic mathematics reform initiative aimed at improving achievement in middle and high school mathematics and algebra. The program is intended to provide students with increased instructional time in mathematics during which they experience challenging instruction supported by the TI-Navigator™ technology. The systemic supports include the creation of 100-minute blocks of mathematics, intensive professional development for teachers, and the establishment of common planning time to build school-based professional learning communities.

In 2007–08, the program had nearly 140 teachers in 35 schools from 11 districts. During this past year, SRI International has been conducting an evaluation of the program, focusing both on program implementation and impacts on student achievement. This report answers questions related to program implementation in the participating schools and districts:

- What are the conditions of implementation in the participating school districts and implications for scalability and sustainability of the program?
- To what extent is MathForward™ being implemented as intended?

Sources of data for the implementation evaluation were surveys conducted of all teachers in the program at three time points during the year and observations and interviews with teachers and administrators in four different regions where the program was being implemented.

Key Findings

- All schools increased time for mathematics instruction for participating students.
- Teachers' professional development experiences were deep, extended, and varied in format.
- Most schools did not provide common planning periods for participating teachers.
- Teachers and students found the TI-Navigator™ technology contributed positively to teaching and learning.
- When using TI-Navigator™, teachers used its formative assessment functions most often.
- Teachers used assessment data to adjust the pace of their instruction.

Findings About Conditions of Implementation

Overall, implementation of the structural supports of the program was strongest in the areas of scheduling and professional development. All schools allocated double blocks for participating students, but complex school schedules made it difficult to assign a continuous 100-minute block in each school.

Teachers' professional development experiences were deep, extended, and varied in format. Teachers valued most the professional development they received from coaches and the informal support they received from teacher-leaders in the schools. A particular strength of the program was the coaching teachers received in the program. Coaches provided teachers with useful feedback, in workshops, in the context of observing and supporting teachers in the classroom, and through ongoing communication with teachers. Teachers reported that content-related professional development in mathematics was most useful in helping them develop new approaches to solving mathematics problems.

One structural support that schools and districts did not adopt as consistently was common planning time for participating teachers. Most schools did not have weekly common planning period in which teachers discussed the program. Although many schools did have time when teachers could meet, other agenda items often took precedence, and when there were few colleagues in the program, MathForward™ was not always an appropriate topic for meetings. MathForward™ was often a topic in schools where multiple teachers were implementing the program.

The evaluation identified some barriers to implementation at the school and district level. The main technical issues teachers faced in using TI-Navigator™ were related to communication, and most issues teachers could address on their own or with the help of colleagues and occasionally a student in their school. However, some teachers reported that their difficulties discouraged them from using the technology with students.

Teachers reported high levels of overall support for their participation in the program from principals, but more agreed than disagreed that their principals were not active in monitoring implementation. Teachers found district leaders distant from the program and had little sense of leaders' involvement in supporting MathForward™.

Findings About Implementation

Teachers and students alike found that the TI-Navigator™ technology contributed positively to teaching and learning. The top benefit of TI-Navigator™ technology, from teachers' point of view, was the information it gives them about what their students know and can do. Most students are excited to use TI-Navigator™, although evaluators observed that its use did not always entail broad and high engagement of students in class.

In part, variability in engagement may be explained by the different instructional strategies that teachers use when employing TI-Navigator™. Teachers used the assessment functions of TI-Navigator™ more readily than they use Activity Center, though with practice most teachers become comfortable with using the features that make TI-Navigator™ unique.

Teachers also varied with respect to the extent that they engaged students in extended discussion of their ideas. When they did engage student ideas, most often discussion took place as part of whole-class instruction or review. Teachers did use the displays in their class so that students could see the distribution of responses to problems in class, but they mainly used the data to speed up or slow down the pace of instruction and not for diagnosis of student thinking.

Some districts enacted more aspects of the program than others. The four dimensions of implementation quality we examined across districts—leadership, professional development, TI-Navigator™ use, and common planning time—appear to be interrelated, since districts that were rated high on one dimension were also often high on others.

Quantitative analyses further suggest a "district effect," but additional research is needed to identify more specifically the critical district-level success factors since there are still a small number of districts in the program. Teachers in districts that had been in the program longer were more likely to use TI-Navigator™ results formatively, that is, to adjust their instruction.

Conclusions and Recommendations

The conditions of implementation over which TI has significant control in MathForward™ are the program's greatest strengths. TI has equipped teachers with sophisticated classroom network technology and prepared them well to use it. Further, it has provided coaching that reflects best practice in teacher professional development.

At the same time, TI has been less successful so far in helping local districts identify ways that they can adapt the program to fit local realities and competing initiatives. The fact that many districts have modified blocks and common planning time as key supports for the program suggests that the image TI has for the program needs some revision. One key recommendation for program improvement is to explore different models for how schools can set up and make the most of block scheduling. We also recommend TI consider integrating more opportunities for regional, off-campus meetings of MathForward™ teachers in the program to share ideas with one another so that the program does not compete directly for teachers' planning time during the regular school day.

With respect to implementation, most teachers made extensive and broad use of TI-Navigator™. At the same time, they used more of its assessment functions and fewer of those functions that make it unique (such as Activity Center). Furthermore, many teachers need assistance in orchestrating discussions of student ideas and thinking in ways that exploit the technology more effectively. Therefore, we recommend that more professional development resources be dedicated to helping teachers make use of student data to support student explanation and justification of their ideas.

Based on its first 3 years, TI's MathForward™ program has much in common with and much to learn from the experience of intermediary organizations that have developed and supported systemic reform models in the past two decades. Like those intermediary organizations that aimed to support schools, TI stands partly outside the system and tries to influence it. Its influence is both enhanced and weakened by that position: TI's credibility with teachers may be higher because TI is not part of the bureaucracy, but at the same time TI has little to no influence on other policies that could undermine implementation. TI can learn from past reform efforts to build teacher ownership over reforms and to engage district leaders in collaborative adaptation of the program designs.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Strategies of MathForward™

- Increased instructional time
- Increased teacher content knowledge
- Common aligned assessments
- Common planning times
- Coaching and professional development
- Use of technology to motivate students
- Curriculum integration
- Administrator/parental support

INTRODUCTION

Goals and Core Components of MathForward™

The Texas Instruments (TI) MathForward™ program is a systemic mathematics reform initiative aimed at improving achievement in middle school mathematics and algebra. The catalyst for reform has been the introduction of the TI-Navigator™ Classroom Learning System, TI-84, and TI-73 Explorer™ graphing calculators, which are intended to increase student participation and engagement in significant mathematics content and to inform both teachers and students about what they know and can do. In addition to the introduction of technology to enhance teaching and learning in the classroom, the MathForward™ program calls for strong administrator involvement and support, deep and ongoing teacher professional development, increased time for mathematics learning, and higher expectations of all students.

The core components of the program draw on scientific research that has addressed how best to meet the goals of MathForward™. Classroom network technologies like the TI-Navigator™ Classroom Learning System have shown the potential for increasing students' participation in class and their conceptual learning (Penuel, Roschelle, & Abrahamson, 2005). Professional development that is of an extended duration, focuses on content and classroom practice, and provides opportunities for teachers to learn from one another has been linked to increased teacher knowledge and improvements in classroom instruction (Desimone, Porter, Garet, Yoon, & Birman, 2002). When students spend more time working on complex assignments in mathematics, they learn more (Rowan, Correnti, & Miller, 2002). Likewise, heightened teacher expectations for students and teachers' perceptions of greater administrative support have been linked to successful teaching and learning outcomes (Jussim & Eccles, 1992; O'Donnell & White, 2005; Rowan, Chiang, & Miller, 1997).

Three components of MathForward™ make it a systemic reform program with potential for broad impact. First, the program promotes alignment of professional development, curriculum, and assessment—a core feature of systemic reform (Knapp, 1997; Spillane & Jennings, 1997). Second, the program targets whole districts and schools for participation rather than individual teachers. Third, MathForward™ calls for changes not only inside the classroom, but also in how schools are organized to support mathematics learning. In these respects, MathForward™ is like certain states' efforts to promote systemic reform in mathematics and science; lessons from studies of implementation of these efforts (e.g., Penuel, Fishman, Gallagher, Korbak, & Lopez-Prado, 2008) regarding the challenges of transforming instruction in a systemic context are thus applicable to MathForward™.

Context and Purpose for the Evaluation

MathForward™ began in the 2005–06 school year with a pilot study in the Richardson Independent School District in the Dallas, Texas, metropolitan area. An evaluation of the pilot showed the potential of the program: Pass rates for at-risk students participating in the program jumped by one-third in the first year. Gains in the 2006–07 school year were similarly strong. In 2006–07, the program expanded to other districts in Texas and to districts in Florida and Ohio. Preliminary evaluation results from the new districts also showed the program's potential for improving student achievement (Alexander & Stroup, 2006; Stroup, Pham, & Alexander, 2007; Winick & Lewis, 2006, 2007a, 2007b, 2007c, 2007d). In 2007–08, the program has expanded to include nearly 140 teachers in 35 schools from 11 districts. (Four of the 11 districts make up the Stark-Summit Collaborative.)

As the program has expanded, so too has the need for rigorous research on it. In summer 2007, Texas Instruments contracted with SRI International (SRI), an independent, nonpartisan research organization, to conduct an evaluation of the MathForward™ program in 11 of the districts implementing it in 2007–08. The purpose of the evaluation was to analyze the effects of MathForward™ on mathematics teaching and learning in participating districts by addressing three evaluation questions.

In leading the evaluation, SRI developed agreements with districts to provide achievement data for MathForward™ and comparison students, for collecting data on classroom practice, and for analyzing data. Dr. Jeff Lewis of the evaluation firm Winick and Lewis collected data on the impacts of the program on teacher knowledge.

Purpose of This Report

The achievement of MathForward™ students is reported separately in district profiles. The purpose of this report is to present analyses of the level of implementation quality in districts participating in the program. The report includes analyses of quality across districts and for each district separately to provide both an overall picture of program implementation and how implementation varies. To analyze conditions of implementation, the report uses a combination of quantitative and qualitative analyses. Quantitative models show which factors predict different dimensions of implementation quality, and qualitative data present teacher perspectives on how conditions in their schools and districts influence their decisions about program implementation.

Throughout the report, we have developed summary statements of findings that appear in boldface in boxes. These summaries integrate data from different sources. In developing the summary statements, we use broad language but certain terms are used consistently. If a statement indicates all schools or teachers share a characteristic, it means that we have one or more sources of data to support the idea that 100 percent of schools or teachers have that characteristic. "Most" qualifies statements that apply to between 51 and 99 percent of schools or teachers, and "some" qualifies statements that apply to between 1 and 49 percent of schools or teachers. "None" applies when evidence indicates no schools or teachers have that characteristic.

The Evaluation Questions

1. How does the mathematics achievement of students in MathForward™ compare with that of a similar group of students who are not in MathForward™?
2. What are the conditions of implementation in the participating school districts and implications for scalability and sustainability of the program?
3. To what extent is MathForward™ being implemented as intended?

SOURCES OF DATA

Teacher Questionnaires

All participating teachers were asked to complete short (20-minute) online surveys at three intervals throughout the school year. The surveys asked teachers to report on the frequency with which they engage in various classroom activities aligned with or connected to the MathForward™ program. The surveys also asked teachers to provide basic background information about themselves (e.g., years of teaching, level of certification).

Teachers completed surveys in November 2007, February 2008, and April 2008. Of the 152 teachers who participated in the program in 2007–08, 115 or 85 percent completed at least one survey. In the fall, a total of 103 teachers completed a survey; in winter, 80 teachers responded to the survey, and 84 responded in the spring. A total of 59 teachers completed all three surveys.

Classroom Observations

SRI worked with TI to select four different regions in which to collect direct observation data. The primary purpose of the classroom observations was to develop richer descriptions of how teachers use TI-Navigator™ to support mathematics instruction than can be generated from survey data. A secondary purpose was to identify examples of particularly promising uses of TI-Navigator™ that could inform designs for professional development.

SRI developed two observation forms for the study. The first was a closed-ended form that captured basic information about the class (e.g., grade level, number of students, level of mathematics), mathematics content that was the focus of instruction, technical problems encountered and how they were addressed, and student engagement. The form also asked observers to indicate what TI-Navigator™ tools teachers used with students and the instructional strategies they used in conjunction with TI-Navigator™. The second form required an ethnographic observer with a strong background in mathematics education (at least 3 years' experience conducting research or teaching in mathematics) to keep a running record of instructional activity. At the end of the class, this observer gave the class a holistic rating with respect to the nature of feedback given to students, the quality of student explanations for answers, the cognitive demand associated with teacher tasks, the nature of student questions, and teachers' use of assessment data to adjust instruction on the fly.

SRI researchers conducted a total of 21 observations in 6 districts and 9 schools in spring 2008. We purposefully selected schools for observations where survey data revealed teachers were making some use of TI-Navigator™ technology. Observations lasted an average of 41 minutes each (range: 25 to 97 minutes). Of the classrooms visited, one was a sixth grade classroom, nine were seventh grade classrooms, nine were eighth grade classrooms, four were ninth grade classrooms, and three were tenth grade classrooms.

Teacher Interviews

SRI conducted interviews in spring 2008 with each of the 21 teachers observed in the four regions. Interviewers followed a structured protocol for all interviews, which covered the topics of how the school allocated time for mathematics instruction, teachers' participation in professional development, use of TI-Navigator™, instruction with TI-Navigator™, and barriers and supports to implementation. Because the interviews were at the end of the school year, teachers' accounts reflected at least 1 year of implementation experience; those accounts may also include bias due to poor memory from distant events and to teachers' reinterpretation of early program experiences based on later ones.

Table 1 summarizes sources of data which inform judgments about each of the major implementation quality indicators and about supports and barriers to implementation.

Table 1. Indicators of Implementation Quality and Evaluation Data Sources

Quality Indicator	Source of Data
Allocation of additional instructional time for mathematics instruction	Questionnaires Teacher interviews
Participation in professional development	Questionnaires Teacher interviews
Frequent and varied use of TI-Navigator	Questionnaires Teacher interviews Classroom observations
Use of interactive teaching methods with TI-Navigator	Questionnaires Teacher interviews Classroom observations
Barriers and supports to implementation Student interest and participation Availability of technical support Principal support District leadership	Questionnaires Teacher interviews Classroom observations

In 2007-08, MathForward™ participants included:

- 11 districts
- 35 schools
- 152 teachers

CHARACTERISTICS OF PARTICIPATING DISTRICTS, SCHOOLS, AND TEACHERS

A total of 11 districts participated in MathForward™ in 2007–08. In some districts, like Richardson ISD in Texas, multiple schools participated; in others, such as the Levittown Public Schools, just one school took part. By far the largest implementation was in Richardson, which was also in its third year of implementation. Four of the Ohio districts (Canton Local, Copley-Fairlawn, Jackson, and Springfield Local) made up the Stark-Summit Collaborative whose teachers participated in joint professional development activities.

Table 2 lists the names and locations of the participating districts. Also indicated are the number of students enrolled in participating schools (which exceeds the number of students in the program in most cases), the number of years the districts have been part of the program, and the number of schools in the program.

Table 2. Characteristics of Participating Districts

	Location	Number of Students*	Years in MathForward™	Number of Schools in Program
Richardson ISD	Texas	14,452	3	13
Dallas ISD	Texas	1,179	2	2
Euclid City Schools	Ohio	1,623	2	2
Palm Beach County School District	Florida	3,704	2	3
Brentwood Union School District	California	1,183	1	1
Canton Local School District (Summit-Stark)	Ohio	1,309	1	2
Copley-Fairlawn City School District	Ohio	1,070	1	1
Jackson Local School District	Ohio	3,229	1	2
Springfield Local School District	Ohio	923	1	2
Hays Independent Schools	Texas	4,403	1	6
Levittown Public Schools	New York	1,347	1	1

Sources: Texas Instruments, NCES Database
*Sum of enrollments of participating schools

Table 3 presents basic information about the demographics of students in each of the participating schools. There were 24 middle schools and 11 high schools in the program in 2007–08. Just under half (45%) of the schools are Title I schools, indicating that they serve primarily low-income students. The median percentage of students who are eligible for free or reduced-price lunch based on their family's income is 41 for the schools. Nineteen of 33 schools for which data are available are "minority-majority" schools, meaning that more than 50 percent of students are nonwhite.

Table 3. Demographic Characteristics of Participating Schools

School	% African-American	% Hispanic	% Asian-American	% White	% Other	% Free/ Reduced-Price Lunch
Richardson ISD						
Apollo JH	20	21	16	43	0	39
Berkner HS	22	16	20	42	0	32
Forest Meadow JH	53	23	4	19	1	64
Lake Highlands Freshmen Center	Information not available from Common Core of Data					
Lake Highlands HS	38	15	3	44	0	33
Lake Highlands JH	46	20	2	32	0	51
Liberty JH	41	22	17	20	0	64
Parkhill JH	8	25	4	63	0	28
Pearce HS	8	20	6	65	1	19
Richardson North HS	21	33	7	40	0	34
Richardson North JH	8	28	4	59	1	33
West JH	21	43	5	31	0	52
Westwood JH	24	35	6	34	1	45
Dallas ISD						
Dade MS	Information not available from Common Core of Data					
Anderson MS	85	14	0	0	1	93
Euclid City Schools						
Euclid Central MS	77	1	0	18	4	59
Forest Park MS	75	0	0	21	4	63
Palm Beach County School District						
Howell Watkins MS	64	7	2	27	0	55
Palm Springs MS	16	53	2	29	0	68
Roosevelt MS	64	16	6	14	0	57
Brentwood Union School District						
Edna Hill MS	7	34	6	52	0	25
Canton Local School District (Summit-Stark)						
Canton South HS	9	1	0	90	0	24
Faircrest Memorial MS	10	1	0	87	2	41
Copley-Fairlawn City School District						
Copley-Fairlawn MS	15	1	5	76	3	11
Jackson Local School District						
Jackson HS	2	0	2	95	1	6
Jackson Memorial MS	2	1	3	95	0	10
Springfield Local School District						
Schrop Intermediate	2	1	1	96	0	42
Spring Hill MS	1	1	2	96	0	42
Hays Independent Schools						
Academy at Hays HS	0	55	0	44	1	27
Armando Chapa MS	Information not available from Common Core of Data					
Dahlstrom MS	4	35	0	61	0	24
Jack C. Hays HS	3	45	1	51	0	27
Lehman HS	7	63	0	29	1	50
R.C. Barton MS	3	54	1	42	0	41
Levittown Public Schools						
MacArthur HS	1	5	4	90	0	7

Source: NCES Database

MathForward™ was implemented in grades 6, 7, 8, 9, and 10 classrooms in 2007–08. Nearly half (48%) of the teachers in the program taught eighth-graders, and 39% taught seventh-graders. Under one-fifth of the teachers in the program were high school teachers (Table 4). A number of teachers taught multiple classes and grade levels of students in the program.

The courses that teachers reported as the focus of program implementation ranged widely, with general mathematics classes for middle school students accounting for the majority of teachers' assignments. Algebra I was a focal class for 28 percent of the teachers in MathForward™ (Table 4).

Table 4. Characteristics of MathForward Classrooms

	Number of Teachers	% of Teachers
Grade Levels		
Sixth	4	3
Seventh	54	39
Eighth	66	48
Ninth	21	15
Tenth	7	5
Subjects		
Elementary math	1	1
Middle school math	62	60
Pre-algebra	32	31
Algebra I	29	28
Geometry	5	5
Integrated math	3	3
Advanced math	4	4
Number of MathForward Classes		
One	46	45
Two or three	41	40
Four	6	6
More than four	10	10

Source: Grade levels, TI Contact Sheets, others, Fall Survey Items 3, 1
n = 103

The teachers in the program had an average of 6 years of teaching experience, and nearly all held a full teaching credential (Table 5). Just under two-thirds (62%) held a single-subject credential in mathematics, and 36 percent held a multisubject credential.

Table 5. Teaching Backgrounds of Participating Teachers

Background Characteristic	Parameter
Years Teaching	
Middle or high school	Mean = 6.4 Standard Deviation = 6.2
Mathematics	Mean = 6.1 Standard Deviation = 4.9
Type of Certificate Held	
Regular or standard certificate	83 (90%)
Probationary, provisional, or temporary	9 (10%)
Single subject in mathematics	57 (62%)
Single subject (not mathematics)	12 (13%)
Multi subject	33 (36%)
Source: Multiple Survey Items *n* = 92	

The vast majority of teachers in the program had taken some courses in mathematics and in mathematics education as part of their preservice training. Half of all teachers had completed five or more courses in mathematics, and more than 80% had taken at least one course in mathematics education (Table 6). Over one-third (36 %) held master's degrees.

Table 6. Subject Matter Preparation of Participating Teachers

Background Characteristic	Number of Teachers with Characteristic
Highest Degree	
Bachelor's degree	46 (63%)
Master's degree	26 (36%)
Educational specialist	1 (<1%)
Coursework in Mathematics	
No courses	7 (9%)
1 or 2 courses	16 (22%)
3 or 4 courses	14 (19%)
5 or more courses	37 (50%)
Coursework in Mathematics Education	
No courses	13 (18%)
1 or 2 courses	18 (24%)
3 or 4 courses	17 (23%)
5 or more courses	25 (34%)
Source: Survey Items W22, W25, W2 $73 \le n \le 74$	

CONDITIONS OF IMPLEMENTATION

In this section, we report on overall implementation patterns across the districts, focusing on the key conditions of implementation quality.

Key Finding

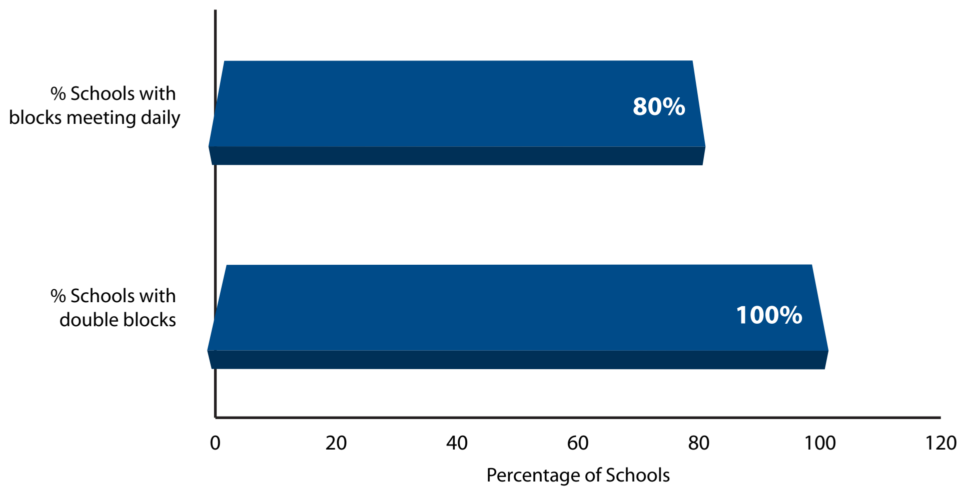
All schools created double blocks for participating students, but complex school schedules made it difficult to assign a continuous, 100-minute block in some schools.

Allocation of Instructional Time

When students spend more time working on complex assignments in mathematics, they learn more (Rowan et al., 2002). MathForward™ seeks to increase the allocation of instructional time for mathematics by requesting that each school create a double-block of mathematics instruction every day for participating students. If possible, blocks are to last 90–100 minutes per day in the program.

According to coaches and survey data, all the schools and districts in the program had created double blocks of mathematics instruction for students participating in MathForward™. Of these, 80 percent allocated a full 100-minute block for MathForward™ students every day (Figure 1).

Figure 1. Structuring of Instructional Blocks in Mathematics



Source: Survey Items F16, F17, TI Coaches

The details and logistics of the block periods vary from school to school, however, and are not as straightforward as one might imagine. Some schools, for example, have created block schedules that are about 90 minutes in length (from about 84 to 94 minutes) while others have full 100-minute blocks. At one school, one of the MathForward™ classes had to be scheduled during a lunch period, which apparently cannot be altered, so that class is only 60 minutes long.

A primary reason why it has not been easy for districts to implement the 90- to 100-minute blocks uniformly is the complexity of school scheduling. Given that regular periods typically last for about 45 minutes, it is easier for schools to create blocks that are simply two periods back-to-back, thus totaling about 90 minutes, rather than create new schedules to accommodate a 100-minute block. In some cases, it was necessary for there to be "interrupted" blocks, in which two periods were separate in time. One teacher had an "interrupted" block in which not all of the students return for the second part of the block period. As a result, the teacher cannot teach new content during that time; instead, she uses the first part of the block for instruction and the second part for additional practice and support for the students who are there.

Our impression is that schools generally try to avoid interrupted blocks. Most all of the teachers who had shortened blocks or blocks that were split by another class voiced their hope that the scheduling would be better next year so that they could have a full, uninterrupted block period.

Interview data indicated teachers' reactions to the benefits of creating double blocks of mathematics instruction varied. In general, the block classes targeted students who were struggling in math, including students who failed a previous math class or students who performed poorly on a standardized assessment. Some teachers who participated in interviews commented that the blocks are helpful for these struggling students, precisely because they need that additional time for instruction and practice. At two schools, however, teachers felt that the blocks did not work very well with the lowest achieving students. Teachers said that these students often despised math and they frequently had discipline problems, making an extended math period particularly difficult for everyone involved. One group of teachers talked about the fact that the blocks—and using the TI calculators in particular—were supposed to bring students to "that next level" in mathematics, but often students in the blocks had little mastery of the basics. The teachers felt they could not use the technology to its fullest potential when the students had not mastered basic math concepts and operations. The same teachers believed that the blocks would have been better suited for students who had basic skills, interest, and motivation but who could benefit from extra help.

Participation in Professional Development

Professional development is an essential support for curriculum and program implementation (Smylie, 1996; Spillane & Jennings, 1997). Participation in professional development was an integral part of the MathForward™ program design for all teachers. Professional development took place within districts or, in the case of the Stark-Summit Collaborative, in a convenient location where teachers from participating districts met together. Professional development included training in how to use TI-Navigator™, instruction with TI-Navigator™, and content-related professional development. Teachers' exposure to different formats of professional development varied, but they took part in formal workshops and received one-on-one mentoring and support from TI coaches.

Key Finding

Most teachers' professional development experiences were deep, extended, and varied in format. Most teachers valued most the professional development they received from coaches and the informal support they received from teacher-leaders in the schools.

Professional Development Related to Instruction with TI-Navigator™

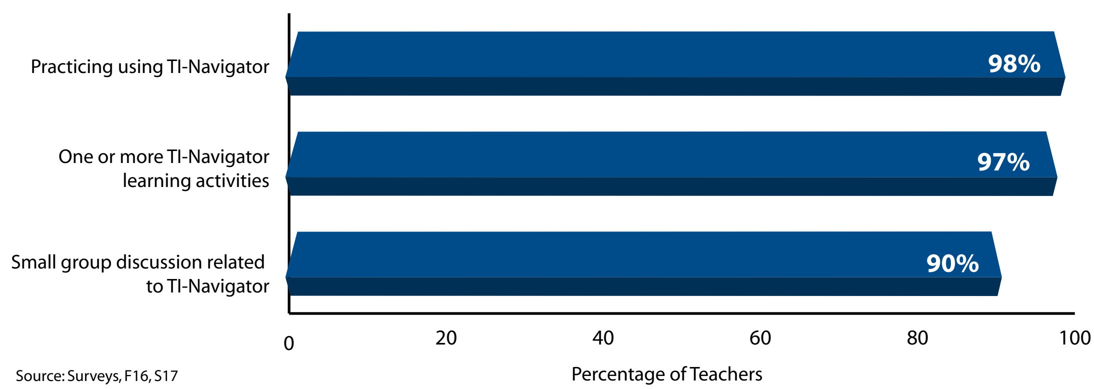
Key Finding

Initial workshops provided most teachers with hands-on experience in learning how to use TI-Navigator™ and allowed them to participate in learning activities with TI-Navigator™.

Studies of effective professional development suggest that it should be hands-on, providing teachers with opportunities to practice what they will be doing with students in the classroom (Fishman & Krajcik, 2003; Garet, Porter, Desimone, Birman, & Yoon, 2001). MathForward™ provides teachers with professional development in the form of workshops in which they gain practice with using TI-Navigator™ technology and with learning activities designed to illustrate how TI-Navigator™ can support the enactment of conceptually challenging mathematics instruction.

Figure 2 shows the three types of activities the overwhelming majority of teachers engaged in as part of the professional development workshops in the MathForward™ program as reported in the surveys. Nearly all teachers reported practicing using TI-Navigator™ (98%) and engaging in one or more TI-Navigator™ learning activities (97%), while 90% also participated in small group discussion related to TI Navigator.

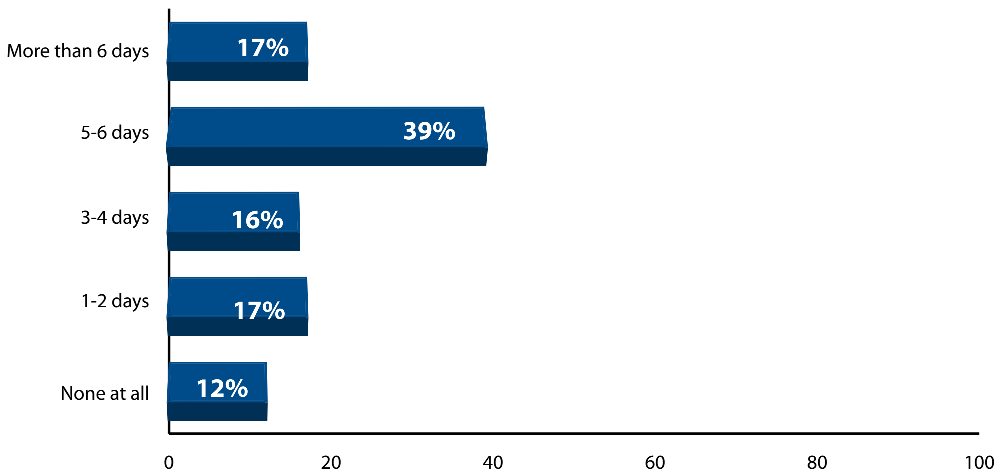
Figure 2. MathForward™ Professional Development Activities



Source: Surveys, F16, S17
n = 105

Attendance at follow-up workshops was common, with 88% of teachers so reporting in surveys. Follow-up professional development activities of this type can enhance the effectiveness of professional development by extending its time span and duration, both of which have been found to be correlated with reported changes to teacher knowledge and practice (Desimone et al., 2002). The most commonly reported amount of time spent on continuing workshops is 5 or 6 days (39%, Figure 3).

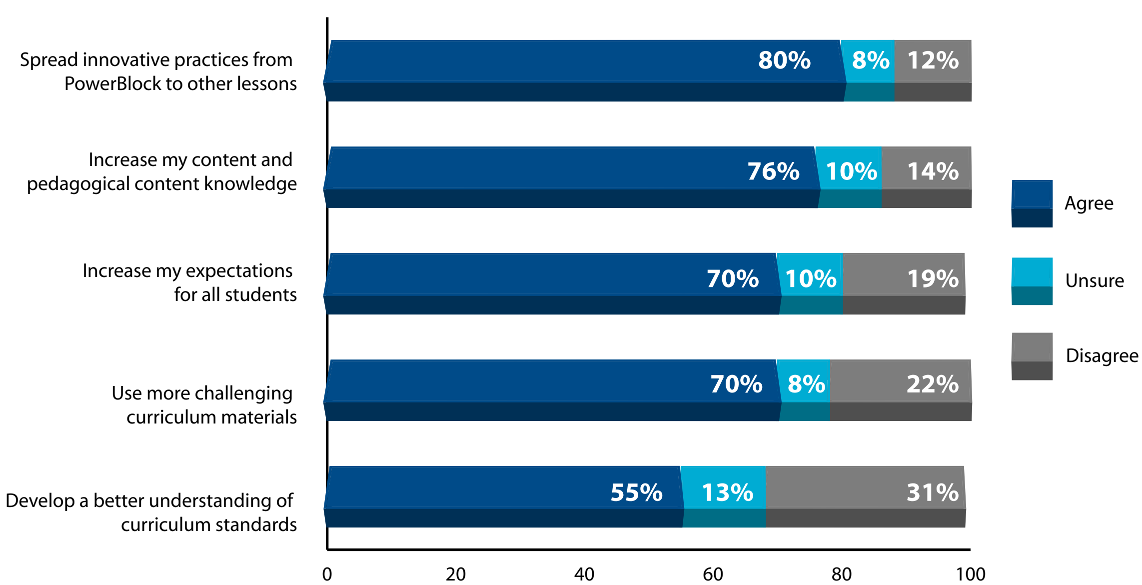
Figure 3. Attendance at Follow-up Workshops



Source: Survey W14, S20
n = 90

Survey data indicated that teachers viewed the workshops as generally beneficial, with most agreeing that the workshops helped them spread innovative practices from PowerBlock to other lessons (80%), increase their content and pedagogical knowledge (76%), increase their expectations for all students (70%), and use more challenging curriculum materials (70%). Fewer teachers (55%) believed the workshops helped them develop a better understanding of curriculum standards (Figure 4).

Figure 4. Perceived Benefits of Professional Development Workshops

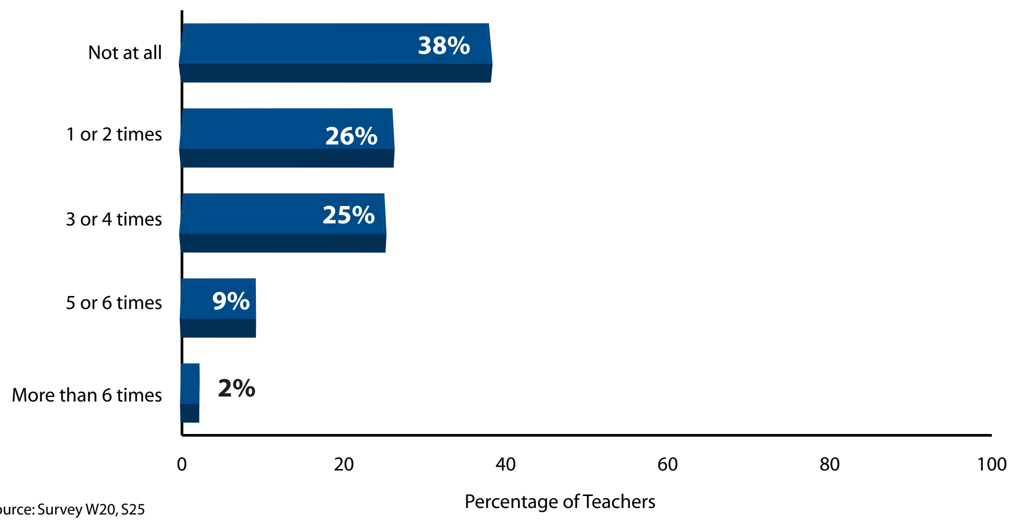


Source: Survey F18, W18, S24
n = 105

Overall, teachers who participated in interviews reported that the professional development workshops were beneficial. Teachers said workshops were useful because they allowed them to see how activities could be implemented in the classroom, learn how to use TI-Navigator™, get ideas for class activities, and ask questions of trainers—activities that teachers often do not have time to do. One teacher commented that the workshops were particularly useful for showing the "range of possibilities" for teaching with TI-Navigator™. Another teacher commented, "Yes, it was valuable because we got to sit down with it [TI-Navigator™] and just interact with it and mess around with it and ask questions, whereas we don't have time for that otherwise." One teacher did criticize the workshops her school's team had received because they did not in her view address differences in teachers' experience and expertise in mathematics.

On average, most teachers (51%) met with their implementation coaches less than twice per month, according to survey data. More than one-third (38%) did not meet with their coaches at all, while only 11% averaged two or more times per month (Figure 4). By design, coaches were to provide assistance to teachers who requested it or who had the greatest need, so it is not surprising that a minority did not meet with coaches during the year.

Figure 5. Frequency (per month) with Which Teachers Met with Implementation Coaches



Source: Survey W20, S25
n = 92

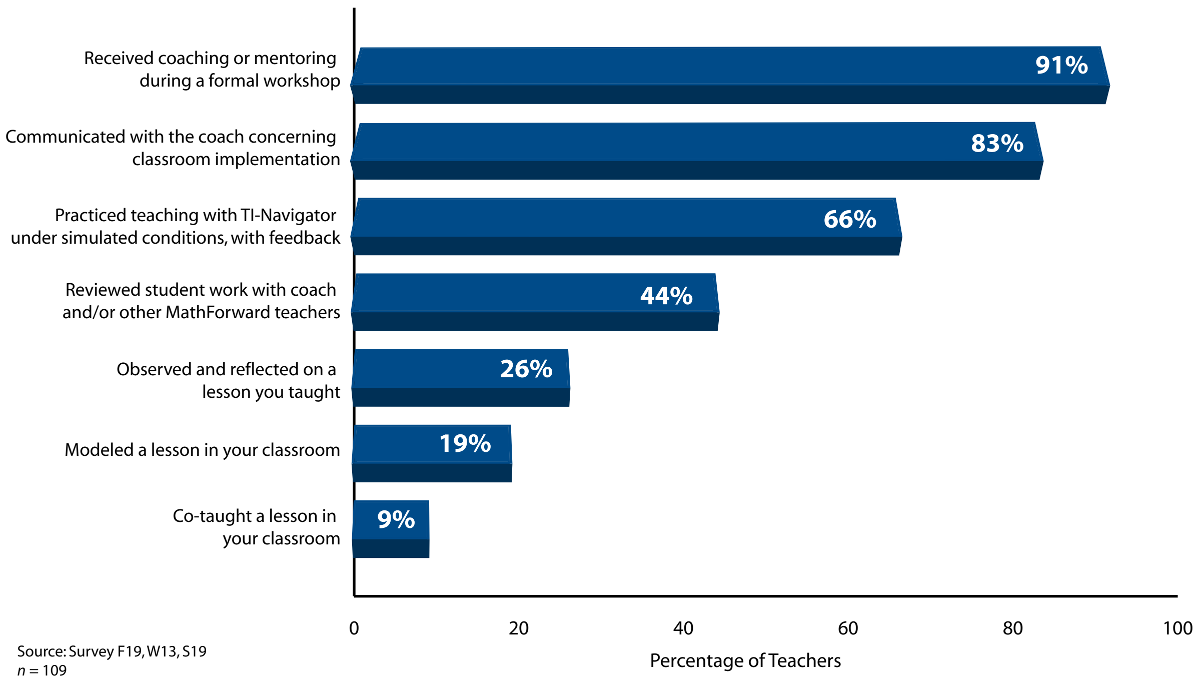
Key Finding

A strength of MathForward™ is the coaching provided to teachers in the program. Coaches gave teachers useful feedback, both in workshops and in the context of observing and supporting them in the classroom.

Receiving feedback from professional developers has been linked to changes in teacher knowledge and practice (Garet et al., 2001) and is an important mechanism in learning more generally for both adults and children (Butler & Winne, 1995). MathForward™ uses its network of coaches assigned to work with schools and districts in the program to provide such feedback to teachers on an ongoing basis.

Most participating teachers received feedback from mentors and coaches in a variety of ways. Commonly reported professional development activities included receiving coaching or mentoring during a formal workshop (91%) and communicating with an implementation coach concerning MathForward™ implementation in the classroom (83%). Almost two-thirds of teachers reported practicing teaching with TI-Navigator™ under simulated conditions with feedback (66%), and almost half reviewed student work with an implementation coach or other MathForward™ teachers (44%) (Figure 6).

Figure 6. Type of Feedback or Guidance Teachers Received from Implementation Coaches or Others



Source: Survey F19, W13, S19
n = 109

In interviews, teachers reported that their coaches were helpful in answering questions about implementation and in providing them with useful feedback. Teachers found particularly valuable coaches' answers to their questions about how to develop TI-Navigator™ activities to teach particular topics. Teachers also valued the one-on-one work with coaches, particularly being observed and then getting feedback from the coach. For example, one teacher commented,

> *She would come on days and just observe in the classroom, usually after she had a coaching day… And so then she was helpful because she was an extra body in here, to help me with technical things and she just has a very good way of knowing how to question kids with a calculator. So just kind of listening to her and what her approach was to having kids use these [TI-Navigator™] was helpful.*

A few teachers also commented that colleagues experienced in using TI-Navigator™ at their school were useful resources to them. For example, one teacher said she found that working closely with an experienced teacher at her school allowed her to anticipate and identify effective strategies and to avoid activities that would not be likely to work with her students. Having a knowledgeable colleague as a resource saved her time and helped to keep her special education class on track with non-special education classes, albeit at a slower pace. Another teacher, new to her particular school, found that meeting with her mentor teacher was very helpful in the beginning stages of using TI-Navigator™ in her algebra class.

Although most teachers interviewed reported their coaches were very responsive, a few were disappointed that their coaches were not as accessible to them as they would have liked. One teacher commented that she could count on a response from her coach within 15 minutes of sending an e-mail. But another teacher from a district in the second year of the program said that her coach was not accessible this year and that she felt isolated. Although teachers at this school meet during their common planning time, she and others interviewed expressed the need for additional support.

Content-Focused Professional Development

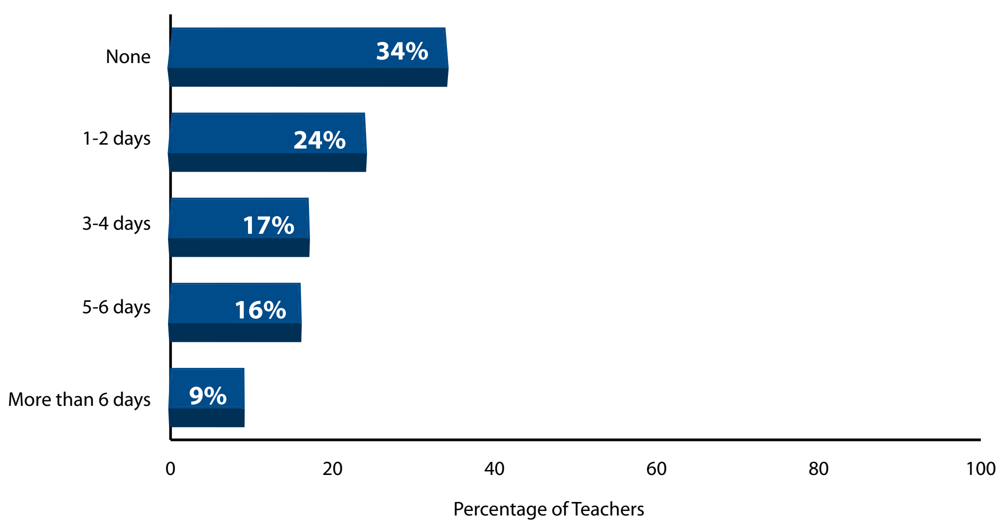
Key Finding

Teachers attended less content-focused professional development than professional development related to program implementation. The most valuable aspect of content-focused professional development was that it provided richer ways to think about mathematical problem solving.

Much attention has been paid in recent years to the importance of content knowledge in mathematics teaching. Policymakers and researchers alike have argued that professional development should be targeted to improve teachers' mathematics content knowledge (Ball & Bass, 2000). MathForward™ aims to improve teachers' content knowledge by providing participating teachers with workshops led by expert mathematicians that are focused primarily on the mathematics topics they are required to teach.

Two-thirds of teachers in MathForward™ participated in content-focused workshops. At the same time, attendance was somewhat less common at content-focused workshops than at the MathForward™ follow-up workshops described above, based on teacher reports in either winter or spring. A third of teachers (34%) did not attend any content workshops, nearly a quarter (24%) attended only 1 or 2 days, and 42% attended 3 or more days of content workshops (Figure 7).

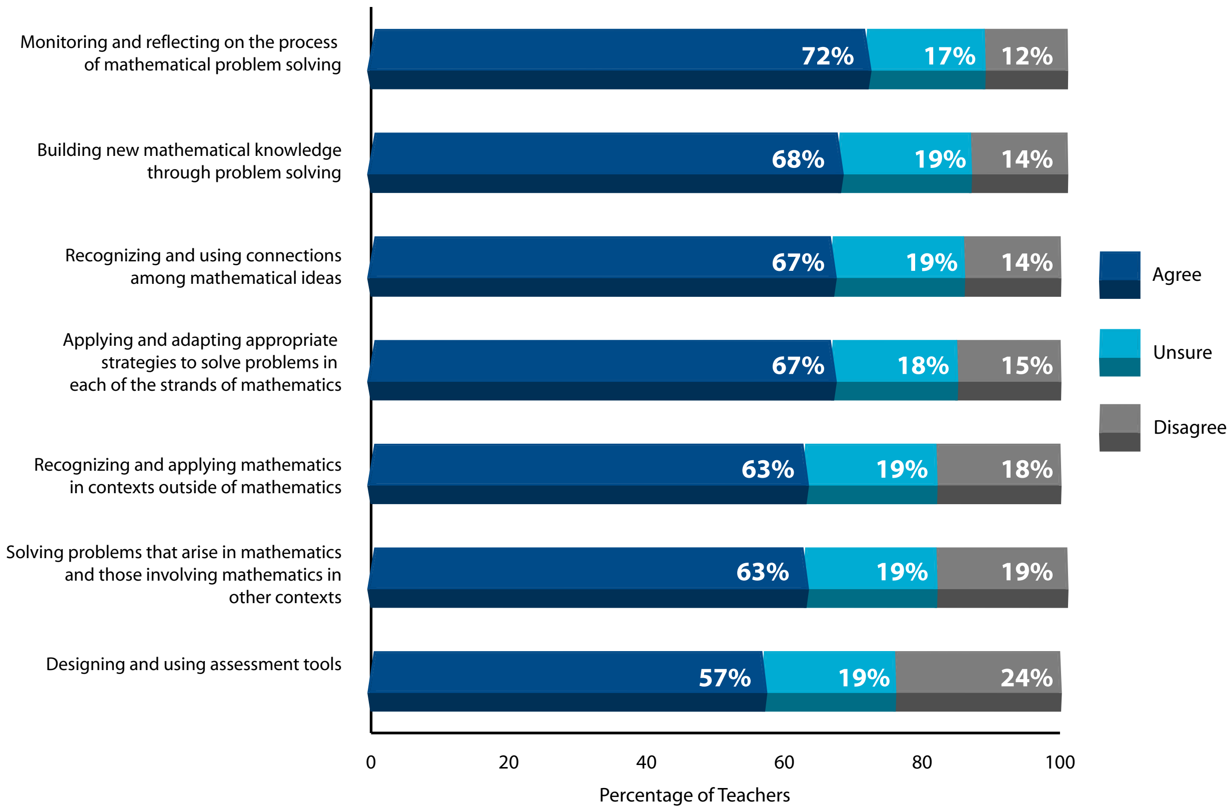
Figure 7. Attendance at Content-Focused Workshops



Source: Survey W15, S21
n = 93
Note: chart indicates percentage of teachers who participated in winter *or* spring.

Overall, teachers agree that content workshops provided opportunities for them to learn more about several different teaching strategies. Almost three quarters (72%) of teachers reported the workshops helped them monitor and reflect on the process of mathematical problem solving, while about two-thirds believed the workshops taught them about building new mathematical knowledge through problem solving (68%), recognizing and applying mathematics in contexts outside of mathematics (67%), and applying and adapting appropriate strategies to solve problems in different strands of mathematics (67%) (Figure 8).

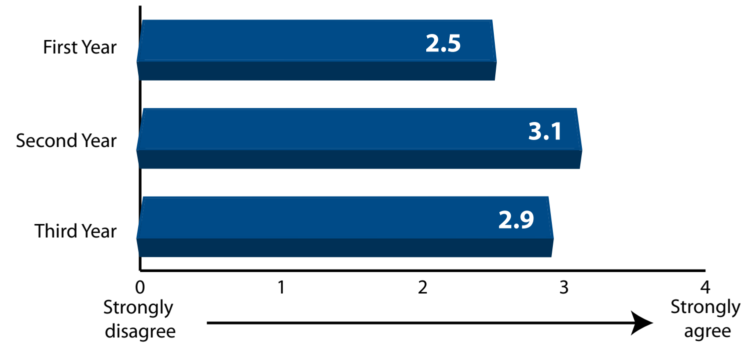
Figure 8. Perceived Benefits of Content-Focused Workshops



Source: Survey W16, S22
$57 \leq n \leq 60$
Notes: chart report data for spring, unless data were missing but available from winter survey.

Across districts, those that were in the second and third years of participation in the MathForward™ program were more likely to report that content workshops were beneficial than teachers in districts in their first year of implementation. On a scale where 0 = strongly disagree and 4 = strongly agree, Year 1 districts averaged 2.5 across the seven ways the content workshops benefited teachers, whereas Year 2 districts averaged 3.1 and Year 3 schools averaged 2.9.

Figure 9. Perceived Benefits of Content-Focused Workshops, By Implementation Year



Source: Survey W16, S22
$57 \leq n \leq 60$
Notes: chart report data for spring, unless data were missing but available from winter survey.

Interview data suggest another factor that contributed to teachers' dissatisfaction with the content-related professional development: its distance from classroom practice. One teacher stated, "With him…you don't see the connection with what you're actually doing in class. There's no pedagogical angle to it." Another teacher, whom many agreed with stated, "The bottom line is… we understand it but how are we going to implement that into the curriculum for our kids?"

In response to this need to relate content to classroom practice, TI has provided some of the mathematician sessions online, with coaches attending and translating the expert's information into practical classroom experiences.

Use of Common Planning Time

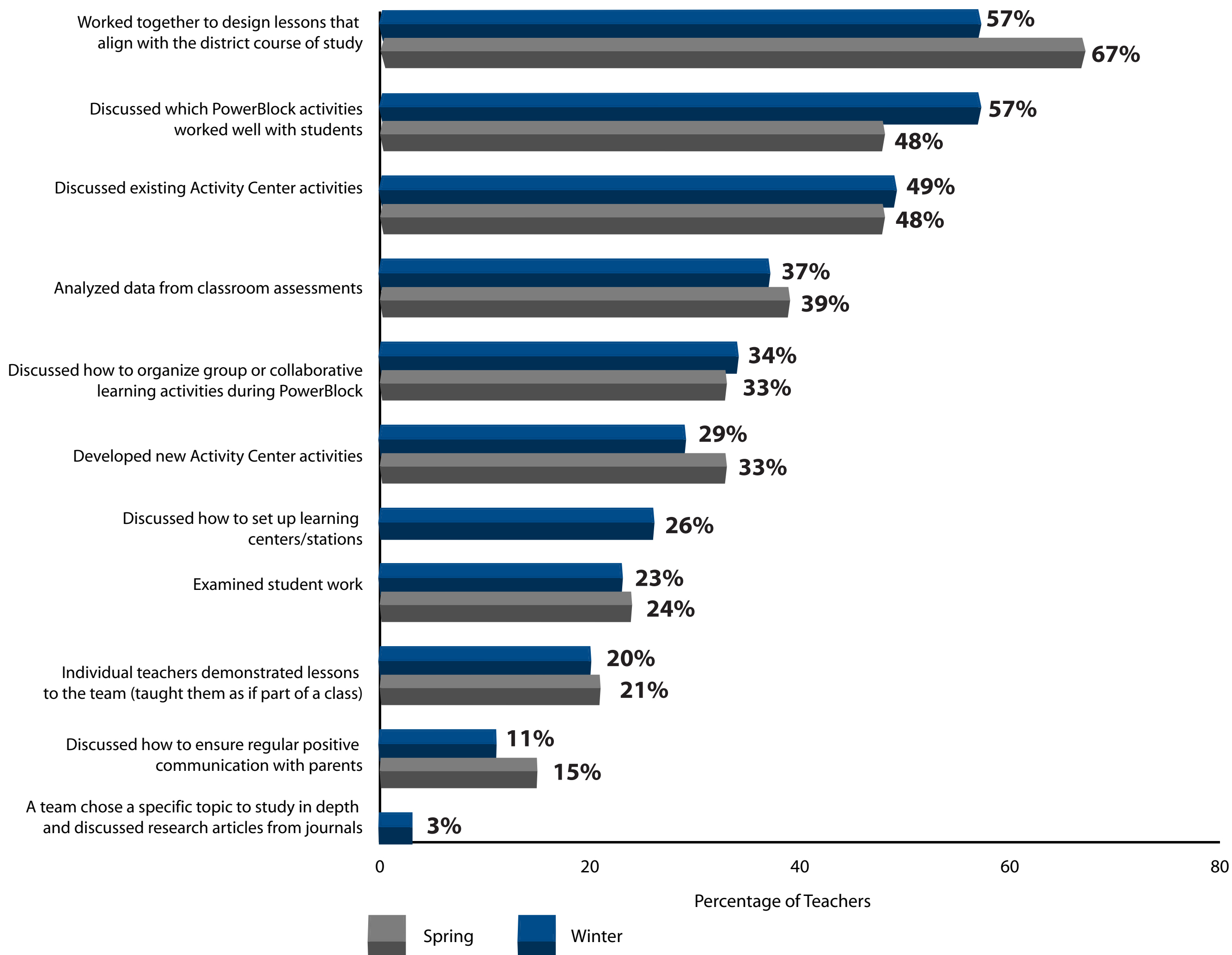
Schools are characterized by a scarcity of time, especially for teacher collaboration (Johnson, 1990; Sizer, 1984). Giving teachers time to meet during a regular part of the workday addresses this barrier directly and provides the conditions for coordinated efforts to scale reforms (Elmore, 1996; Elmore, Peterson, & McCarthey, 1996). Schools participating in MathForward™ are asked to provide weekly common planning time for teachers in the program. The intent is for teachers to use this time for planning and discussing instructional strategies and student learning in mathematics.

Key Finding

Most schools did not have a weekly common planning period in which teachers discussed the program every time they met, although MathForward™ was sometimes a topic in schools where multiple teachers were implementing it.

On average, teachers reported 1.2 periods of common planning time in the month preceding the winter survey and 1.1 periods in the month preceding the spring survey, with a range of 0 to 5 or more periods for each survey administration ($72 \leq n \leq 76$). Teachers used common planning time in several ways, as shown in Figure 10. The most commonly reported was working together to design lessons that align with the district course of study, which was more common in spring (67%) than winter (57%). Other common uses included discussing which Power Block activities worked well with students (57% and 48% in winter and spring, respectively), discussing existing Activity Center activities (49% and 48%), and analyzing data from classroom assessments (37% and 39%). The least common focus was the choice of a specific topic of in-depth study and discussion of articles from research journals on that topic (3% and 0%), followed by discussion of how to ensure regular positive communication with parents (11% and 15%). Data do not allow us to infer what percentage of all common planning periods these topics represented.

Figure 10. Focus of Common Planning Time



Source: Survey W21, S27
$33 \leq n \leq 35$

Teachers provided more details during their interviews about how often and in what teams they met to plan instruction together. Most of the teachers we interviewed reported their school had formalized common planning time that was built in to the school schedule. However, the duration and frequency of those meetings varied from school to school. Moreover, the group of teachers who are supposed to meet differed from school to school: Some teachers met as departments, and others met as grade-level teams, small learning community teams, and teachers who taught the same course.

Among the teachers interviewed, MathForward™ was only one possible topic for discussion during common planning periods. Many teachers explained that the common planning time was also the only time they have to take care of other business—making photocopies, grading papers—so that it is not always possible to meet with other teachers during that time. To supplement the scheduled collaboration times, many teachers said that they met with colleagues during lunch or before or after school. Still others commented that despite the fact their school allocated common planning time, they did not necessarily get along with or share the same philosophy as other teachers on their team and consequently, rarely collaborated, even though they shared a common planning period.

Common planning periods were more likely to focus on MathForward™ when most teachers on the team were in the program. Teachers in those situations said that they shared ideas for incorporating the technology into their lessons, tried out different lesson ideas together and got feedback from each other, traded activities, and so forth. Regular team meetings that included non-MathForward™ teachers did not focus on the program; however, MathForward™ teachers said that within those groups they brought up connections to MathForward™ as they arose. When only one teacher in a grade level was using MathForward™, it was very difficult to strategize about the use of TI-Navigator™ with colleagues.

Barriers and Supports to Implementation

Student Interest and Participation

Student interest and participation can either spur teachers to higher levels of MathForward™ implementation or, if they perceive students are not engaged, lead them to dismiss the program or reduce their effort in implementation. In fact, most studies of classroom network technology suggest that student interest and participation are likely to spur rather than inhibit implementation (Penuel et al., 2005; Roschelle, Penuel, & Abrahamson, 2004).

Key Finding

Most students were excited to use TI-Navigator™, but its use did not always generate broad and high engagement of students in class.

According to observers, just over half (12 of 21) of the classrooms had students who were all or mostly engaged in class. This finding is somewhat surprising, since past studies have reported one of the key advantages of classroom network technology is heightened if not ubiquitous engagement in learning activities. Even in these classrooms, participation in discussion tended to be limited to a few students; use of TI-Navigator™ did not appear to be associated with broad verbal participation, even when students were solving problems posed to them in ways that would make visible whether or not they understood the content. For example, in two classrooms in a school where we observed teachers using Quick Poll to pose problems for students to solve, the teachers rarely gave enough time for or required all students to answer. For most questions posed, between half and two-thirds of the class responded using TI-Navigator™. In between problems, neither of these teachers encouraged student discussion of ideas, and very few students in class volunteered ideas or asked their own questions.

Many teachers believed that overall, student interest and participation were supports to implementation, since students were excited to use TI-Navigator™ in the classroom. Some teachers reported feeling pressure from students to use the system, and one teacher reported that students were disappointed whenever she announced at the beginning of class that TI-Navigator™ would not be used that day. One teacher was surprised by the excitement it generated at school.

For us, this is the first time they ever saw anything like this. I think they really did like it. Even that class, this one kid said to me, 'You know, not everyone uses that Navigator machine, we're like one of the only classes.' I was like, 'How did you know that?' He goes, 'I was asking my friend.' That was so funny to me that they are actually talking about it.

Some teachers reported different effects for different groups of students as well. For lower achieving students technology use was challenging, but when students figured out how to use TI-Navigator™ they were encouraged to be more engaged in class activities. Teachers explained that lower achieving students felt that when TI-Navigator™ was used, they needed to respond to questions because they were held more accountable since the teacher knew which students did not answer. In several classrooms, TI-Navigator™ also allowed quiet students to become more involved in class discussion. Teachers found that quiet students were more apt to speak up and participate because they were more confident that they responded correctly. One teacher stated, "And then because it's on the board and they know everyone's looking at it, they'll actually speak up, speak out to the class. So I think in a way that's actually good because it doesn't keep them quiet. The quiet ones will be the one helping."

Technical Support

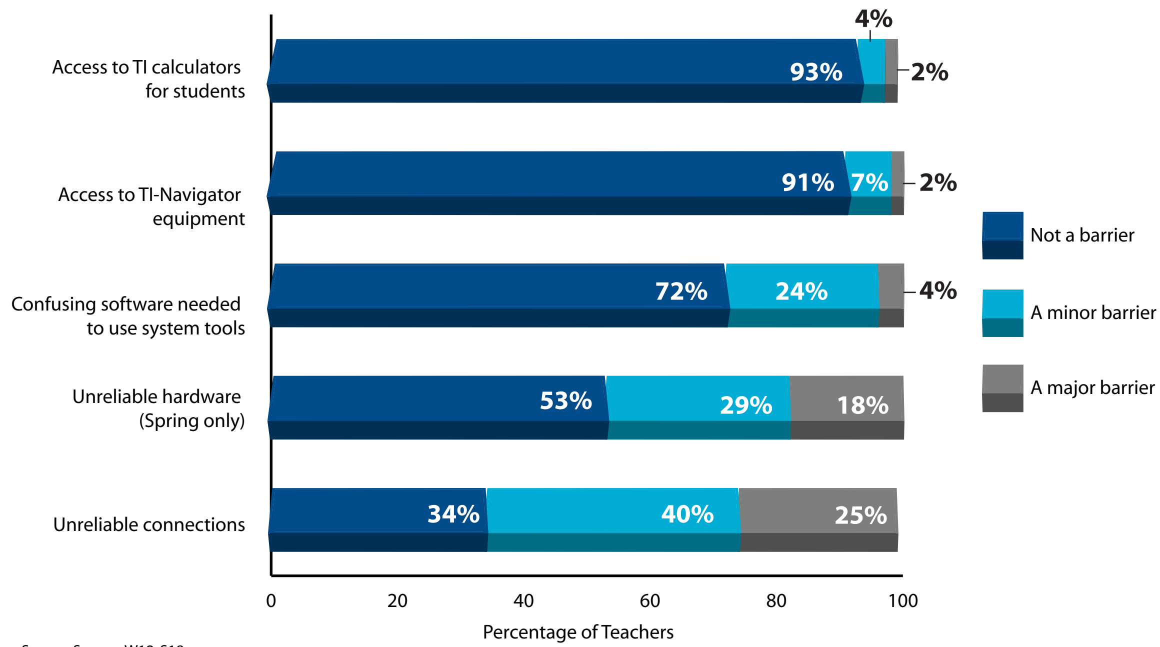
Technical issues and access to technical support are well-known factors in implementation of innovations that use cutting-edge technology (Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000; Newhouse & Rennie, 2001; Sherman, Kleiman, & Peterson, 2004; Silvernail & Harris, 2003; Windschitl & Sahl, 2002). TI-Navigator™ requires many components, including some hardware (e.g., a teacher laptop) that TI did not design. To support teachers, TI has a team of technical support staff who can assist MathForward™ teachers who are experiencing difficulties. We report here technology issues as described by teachers during school year 2007–08. Note that TI's product developers are now aware of and addressing these issues.

Technology access and reliability issues did affect many teachers' implementation levels, according to surveys. The most commonly reported barrier to the use of MathForward™ was unreliable connections between system tools, with 25% of teachers finding it to be a major barrier and another 40% finding it a minor barrier (Figure 11). The second most common issue was unreliable hardware, with 47% of teachers finding it to be a major or minor barrier. Much less common major or minor barriers were confusing software needed to use the system tools (28%), lack of access to TI-Navigator™ equipment (9%), and lack of access to TI calculators for students (7%). Over time, the proportion of teachers who found unreliable connections and confusing software to be either major or minor barriers to the use of MathForward™ increased, while the percentage of teachers who found lack of access to TI-Navigator™ equipment or TI calculators dropped slightly from winter to spring survey administrations.

Key Finding

The main technical issues most teachers faced in using TI-Navigator™ were related to communication, and most teachers could address most issues on their own or with the help of colleagues in their school.

Figure 11. Percentage of Teachers Reporting Technical Issues as Barriers to Implementation



Source: Survey W12, S18
$73 \leq n \leq 78$

On the basis of the interview data, we further analyzed the types of technology problems that teachers encounter when using TI-Navigator™. Table 7 shows which districts reported which types of problems. We also examined the types of problems that teachers reported they could solve on their own compared with those on which they typically sought technical support. Table 8 shows the results of this analysis.

Table 7. Technology Problems By District
(For districts where researchers conducted interviews)

Problem Type	Specific Tech Problem	Brentwood, CA	Levittown, NY	Euclid, OH	Stark-Summit, OH	Dallas, TX	Richardson, TX
Connection/ communication	Connection/communication errors (e.g., problems with cables, hubs, dongles)	●	●	●	●	●	●
	TI-Navigator not available	●				●	
	TI-Navigator shuts down/disappears	●			●		
Calculator functions	Odd calculator difficulties	●					
	Calculator will not turn on and/or shuts off randomly		●				
Problems with applications / files	Applications and/or files disappear from a student's calculator (e.g., get deleted and need to be reloaded)		●			●	
	Corrupt file				●		
Other problems	Memory problems (e.g., "memory full")	●				●	
	Problems installing TI-Navigator software (e.g., old computer operating systems)				●		
	Wireless interference problems (e.g., wireless signals and TI-Navigator interface with one another)			●	●		
	Problems connecting Air Slate to TI-Navigator						●

Table 8. Technology Problems Teachers Solve on Their Own or with Support

Problem Type	Problems Teachers Solved on Their Own	Problems for Which Teachers Sought Support
Connection/ communication	Connection/communication errors (e.g., problems with cables, hubs, connectors)	Connection/communication errors, if not fixed by the known solutions*
	TI-Navigator not available (e.g., access point not working)	TI-Navigator not available (e.g., access point not working)
	TI-Navigator shuts down/disappears	TI-Navigator shuts down/disappears
Calculator functions	Odd calculator difficulties (e.g., lighten and darken the screen; switch out of scientific notation, etc.)	Odd calculator difficulties (e.g., where an image appears on the screen and will not go away)
		Calculator will not turn on and/or shuts off randomly
Problems with applications/ files	Applications and/or fields disappear from a student's calculator (e. g., get deleted and need to be reloaded)	
	Corrupt file**	
Other problems	Memory problems (e.g., "memory full")	Memory problems (e.g., "memory full")
		Problems installing TI-Navigator software (e.g., old computer operating systems)
		Wireless interference problems (e.g., wireless signals and TI-Navigator interface with one another)
		Problems connecting Air Slate to TI-Navigator

*It was much more common for teachers to solve connection and communication errors on their own (particularly those stemming from problems with cables, hubs, or dongles). In some cases, teachers had to get support the very first time the problem arose, but from then on they could solve the problem on their own.
**The teacher did not seek technical support, but also did not resolve the problem individually; the problem remained unresolved and the teacher skipped the activity.

Analysis of interview data indicated that the most common types of technical problems teachers encountered with TI-Navigator™ were connection and communication problems. By and large, teachers could solve these problems on their own. A few teachers mentioned that they had to call support the first time they had a communication error but that they were able to solve similar problems on their own thereafter.

Sometimes the communication/connection problems were related to the cords, the connectors, or the hubs. Teachers commented that the cords were very weak and broke often; the connectors also frequently broke off when connecting to the calculators because they are small and fragile. As a solution to the weakness of the cords, a number of teachers had extra cords on hand, so that they could easily replace a broken cord with a new one. Another common solution to the communication or connection error was to simply unplug and plug it in again, or to log off and log back in again.

In the interviews, we found more variation in teachers' reactions to the technology problems than in the technology problems themselves. Some teachers said communication problems were a minor nuisance but that they had quick and easy solutions and that the class was only minimally disrupted. In many cases, teachers even reported that students had learned how to solve these problems and could do so without interrupting the class. The fact that students could fix common problems on their own makes things even easier on teachers. One teacher said,

> *[Students] do everything now for me in every class. They'll actually stand up, unplug, replug. If I have a communication error, they take care of it themselves. I rarely have to do anything any more. It's nice.*

In contrast, other teachers found the same technology problems to be a major frustration, both for the teacher and the students. One teacher said, "Some days it can be like, Well, there's no wonder this is 2 hours. I need the full 2 hours just because of the communication failures." The fact that the problems occurred regularly and that the teacher and/or the student had to stop what they were doing to diagnose and resolve them meant that these teachers found even simple technology interferences a major deterrent to using TI-Navigator™.

Principal Support

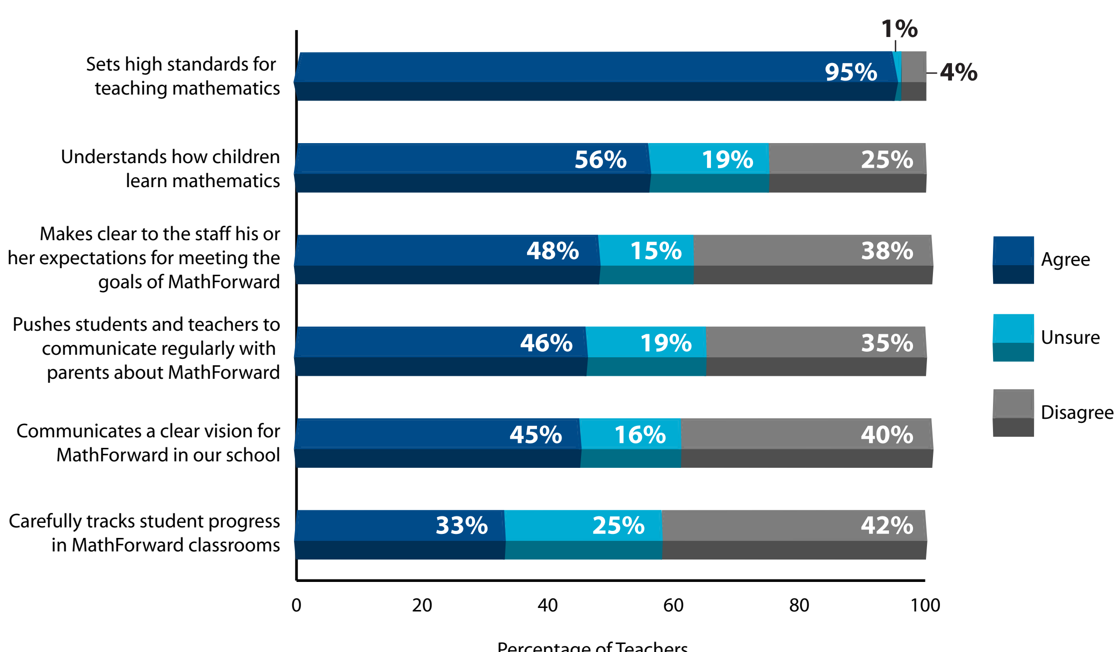
Greater administrative support has been linked to successful teaching and learning outcomes (O'Donnell & White, 2005; Rowan, Chiang, & Miller, 1997). MathForward™ depends on principal support to implement key aspects of the program, including block scheduling and common planning time.

Key Finding

Most teachers reported high overall support from principals, but more agreed than disagreed that their principals were not active in monitoring implementation.

Teachers overwhelmingly agreed that their principals set high standards for teaching mathematics (95%) but were in less agreement about other aspects of principal support for implementation of MathForward™ (Figure 12). Just over half of teachers agreed that their principals understand how children learn mathematics (56%), but less than half believe principals make clear to the staff the expectations for meeting the goals of MathForward™ (48%), push students and teachers to communicate regularly with parents about MathForward™ (46%), communicate a clear vision for MathForward™ in their schools (45%), and carefully track student progress in MathForward™ classrooms (33%).

Figure 12. Teachers' Ratings of Principal Support for MathForward™



Source: Survey F22, W25, S30
n = 96

District Leadership

District leadership is essential in systemic reform efforts in that district leaders and processes are key to distributing the resources and building support for ambitious instructional reforms (Supovitz, 2007). MathForward™ is first and foremost a district-level initiative, and the program looks to district leadership to provide participating schools and teachers the guidance and resources they need to be successful in implementing the program.

Relative to principal support, teachers interviewed reported somewhat less support from district leaders for participation in MathForward™. About half the teachers reported that a district support staff person was very helpful, but the other half felt that district support was lacking or nonexistent. Some teachers felt that there was little to no communication between the school and district about the program, no efforts from the district to recognize their work with it, and a general lack of awareness about program implementation. One teacher noted:

> *One of the assistant principals came to visit my class, the first period class, because they wanted to see how we were integrating the technology and I guess that was I think the only time.…But we don't see district administrators a lot, because they are so far removed from us, usually everything goes through [our department chair] that needs to go up to district, so we report to her and she reports it to district and we really follow that chain of command.*

We conjecture that low levels of district support perceived by teachers could have multiple causes. One could be teachers' access to information about district leaders' actual involvement in supporting the program at the district level. Another could be the size of the district, which could exacerbate problems related to teachers' access to information about district leaders' activity. Another cause could be that school leaders, not district leaders, were in fact the champions for the program at the district.

Key Finding

Most teachers found district leaders distant from the program and had little sense of their involvement in supporting MathForward™.

CLASSROOM IMPLEMENTATION

In this section, we report on overall implementation patterns across the districts, focusing on what teachers did in the classroom.

Use of TI-Navigator™

Overall Value of TI-Navigator™

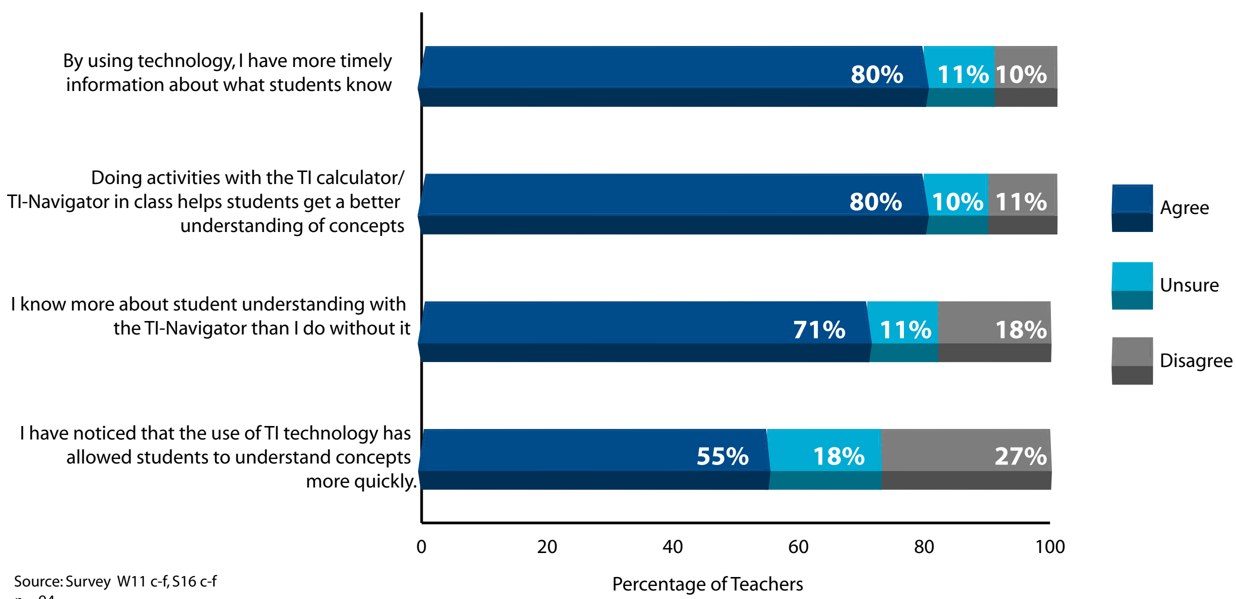
Key Finding

The top benefits of TI-Navigator™ technology, from most teachers' point of view, were more immediate feedback about what students know and can do and enhanced student conceptual understanding of mathematics.

A critical factor in whether teachers use technology in the classroom is their belief in its value (Windschitl & Sahl, 2002). TI builds teachers' interest in the potential of TI-Navigator™ technology by highlighting prospective benefits to teachers in terms they can readily appreciate. Specifically, TI emphasizes that the technology can support higher levels of engagement and participation, improved feedback to teachers about how students are doing, and improved achievement.

Overall, teachers reported many perceived benefits of using TI-Navigator™ in the classroom. More than three-quarters (80%) of teachers felt that using TI technology gave them more timely information about what students know and helped students get a better understanding of concepts. Slightly fewer (71%) believed they know more about student understanding with TI Navigator than without it, and just over half (55%) noticed that using TI technology has allowed students to understand concepts more quickly (Figure 13).

Figure 13. Perceived Value of TI-Navigator™ (overall)



Source: Survey W11 c-f, S16 c-f
n = 94

Throughout the interviews, teachers mentioned a wide variety of benefits of TI-Navigator™. Table 9 shows the categories of benefits that teachers value about TI-Navigator™ and the number of teachers who mentioned each one.

Table 9. Perceived Value of TI-Navigator for Teachers

Aspect	No. of Teachers
Provides immediate feedback for teachers	13
Promotes full-class participation	7
Increases student engagement	6
Fosters conversations about math	4
Saves time	3
Helps demonstrate concepts/student understanding	2
Promotes interactivity/hands-on nature	2
Improves discipline	1
Keeps the teacher engaged	1
Provides students with anonymity	1
Improves classroom management	1

Source: Interviews
n = 31

I think it [TI-Navigator™] is definitely beneficial, because I can see all of their responses quickly, instead of walking around, and having to ask, "Who got this one correct?"

—Participating Teacher

The most common benefit that teachers cited in interviews was the immediate feedback that TI-Navigator™ provides about student understanding (13 teachers). Teachers commonly used data from TI-Navigator™ to determine which problems they needed to review as a whole class and which they could safely skip. Sometimes teachers also used the assessment information to identify topics the class was struggling with and that might therefore merit reteaching. In general, teachers appreciated the fact that this instant feedback gave them some insight into what students were thinking and understanding. One teacher said, "I love the use of feedback. That's the best part for me. … You can't beat it. You know exactly what they're thinking all the time." In another illustrative quote, a teacher commented,

> *I think it [TI-Navigator™] is definitely beneficial, because I can see all of their responses quickly, instead of walking around, if I ask, "Who got this one correct?" Or "Who has a question on it?" They won't ask me. But if they send in their answer, I can see four people put the wrong answer. So I know I have to go over it. I think in that case it is definitely beneficial.*

By displaying student screen shots and responses, teachers said TI-Navigator™ also allowed them to know immediately which students were or were not participating. Once they knew who was not on task, teachers could take steps to ensure that everyone participated appropriately. Indeed, the second most common response that teachers gave about the value of TI-Navigator™ was that it enabled them to promote whole-class participation in learning (7 teachers).

I just like that they... can contribute points, equation lines and things like that. I like that they can contribute to it and they move around and it is interactive with them. I can send them things, they can send me things, and then we can talk about it, up on the board there.

—Participating Teacher

A number of teachers also believed that using TI-Navigator™ increased student engagement in their math classes (6 teachers), according to interview data. Teachers said that students particularly liked being able to see their responses on the screen at the front of the class; many teachers commented that students often raced to see who could submit a correct answer first. At one school, teachers have explicitly capitalized on students' competitive nature, creating a game called "Fast Fingering" and awarding prizes to the first student to submit a correct answer.

Another way that teachers believed TI-Navigator™ increased student engagement was by enabling them to participate actively in class activities. Two teachers explicitly said that they valued the interactive and hands-on learning opportunities that TI-Navigator™ provided. In MathForward™ classrooms, every student had his/her own calculator, and the calculators were all connected to one another (and to the teacher's computer) through a network. This setup meant that every student could do his/her own work on the calculator, experimenting with equations, graphs, points, and so forth. Moreover, students could share their work with the class, contribute to a collective activity or product, and generally interact with one another around the mathematics. According to one teacher,

> *I just like that they—like I said before, they can contribute points, equation lines and things like that. I like that they can contribute to it and they move around and it is interactive with them. I can send them things, they can send me things, and then we can talk about it, up on the board there.*

That teacher's comment also illustrates another perceived benefit of TI-Navigator™—namely, that it can catalyze conversations about mathematics. Specifically, four teachers said that they value the strong math-focused conversations that TI-Navigator™ supports. When asked what she valued most about TI-Navigator™, one teacher replied,

> *Oh, the conversation it generates about answers to questions.… I get such a conversation about, okay, the person who got this answer, what did they forget to do? What did they do wrong? So to me that's the most valuable piece … conversations about finding mistakes, what went wrong, and then also getting answers.*

The conversations that teachers described in interviews often connected to the immediate feedback provided by TI-Navigator™: Because teachers and students can see which incorrect answer choices students selected, they can discuss what those students might have done wrong. In a related vein, two teachers said that one of the benefits of TI-Navigator™ was that it allowed them to demonstrate mathematics concepts to students in a way that supported the development of their deeper conceptual understanding. Using TI-Navigator™, teachers and students can create and manipulate graphs, tables, and equations with relative ease. This feature has the potential to enable students to make connections among different mathematical representations and build an understanding of fundamental mathematics concepts. As one teacher commented,

> *[The greatest value of Navigator is] its use in demonstrating graphing concepts, instead of me ... or the students having to crunch out, you know, seven or eight or nine different graphs to see a relationship, it happens very quickly. And I think that's wonderful. So the kids can quickly grasp the concept in a relationship, as opposed to having to grind out a bunch of different things, in order to catch that, if they ever do.*

Although some teachers were concerned that using TI-Navigator™ took up too much class time, others said that one of the benefits of TI-Navigator™ was that it saved time. Specifically, some teachers said they appreciated that TI-Navigator™ saved them the time they otherwise would have spent to collect, grade, analyze, and return class assessments. Another teacher said he appreciated the fact that TI-Navigator™ made it possible to jump straight to important mathematical discussions, rather than first having to waste time creating graphs and equations to use in demonstrations. In addition, teachers cited support for classroom management, improved discipline, student anonymity, and teacher engagement as valuable aspects of using Navigator in class.

Use of Specific Navigator Functions

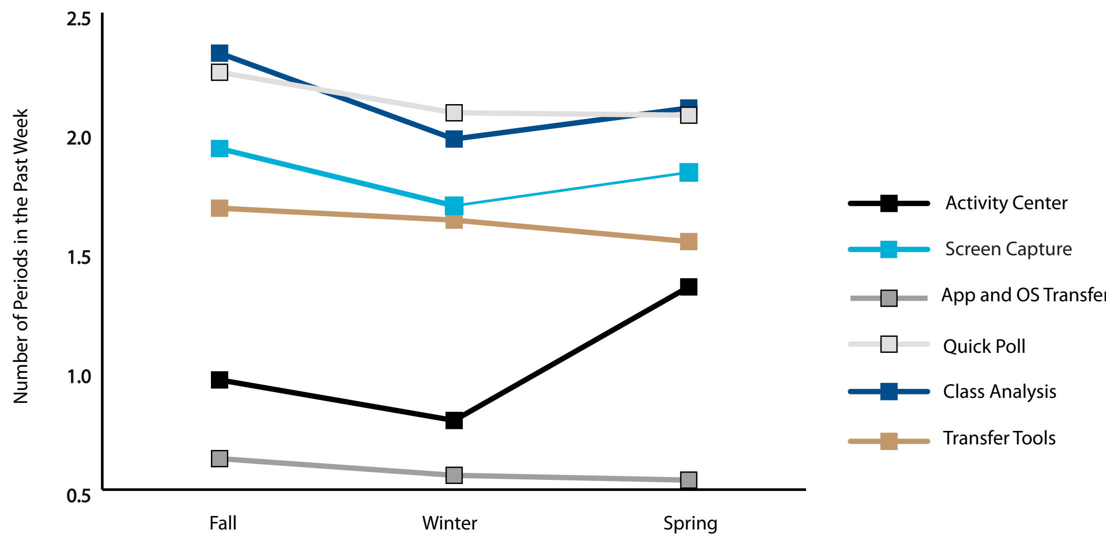
Classroom network technology today can support more than just classroom assessment; cutting-edge technology can also support new forms of participation in subject matter learning (Hegedus & Penuel, 2008). TI-Navigator™ technology's Quick Poll and Learn Check both support assessment in the way that classroom communication systems of the past have done, but its Activity Center allows new forms of participation in mathematics discussions for students (Kaput & Hegedus, 2002). TI encourages teachers in MathForward™ to use a wide range of TI-Navigator™ functions, both for assessment and to promote student participation in class.

Key Finding

Most teachers used the assessment functions of TI-Navigator™ more readily than the Activity Center, though with practice most teachers became comfortable with using the features that make TI-Navigator™ unique.

As shown in Figure 14, the average frequency of use of the different TI-Navigator™ functions dropped slightly from fall to spring survey administrations, except for use of Activity Center, which rose from just under one period of use per week in fall to almost 1.5 periods in spring. The additional Activity Center use was the main reason for an overall increase in TI-Navigator™ use from fall to spring. Class Analysis and Quick Poll remained the two most frequently used functions, followed closely by Screen Capture and Transfer Tools and, in the spring survey, Activity Center. The least used function is App and OS Transfer, reportedly used just over half a period each week.

Figure 14. Frequency of Use of TI-Navigator™ Functions



Source: Survey F9, W4, S10
56 ≤ *n* ≤ 59

Observation data are consistent with what teachers reported they used most often: Observers recorded teachers used one of the two response system functions (Quick Poll and Learn Check) in 81 percent of observations. By contrast, teachers used Activity Center in 43 percent of activities and Screen Capture in just 29 percent of activities (see Table 10).

Table 10. Percentage of Observations in Which Teachers Used TI-Navigator Functions

Function	Percent
Quick Poll	57
Learn Check	57
Activity Center	43
Screen Capture	29
Application and OS Transfer	0

Source: Observation Item 12
n = 21

Interview data suggest that one explanation for this pattern of use is the relative ease of use of different TI-Navigator™ functions. Nearly all teachers interviewed said that Quick Poll and Learn Check were easiest to use of all the Navigator functions, with many teachers reporting use of both functions. In fact, many teachers stated that they used Quick Poll daily, often to review homework or for warm-up activities. Teachers described both functions as also providing them with immediate feedback and as motivating to students. One teacher explained why both she and her students like using Quick Poll this way:

> *I love Quick Polls and my students love Quick Polls because if I want to do just one question right then I can send them a Quick Poll and get a response and then we can move on to another discussion. Then I can form another Quick Poll. And that way I feel and they feel like they are more involved with lessons.*

I love Quick Polls and my students love Quick Polls because if I want to do just one question right then I can send them a Quick Poll and get a response and then we can move on to another discussion. Then I can form another Quick Poll. And that way I feel and they feel like they are more involved with lessons.

—Participating Teacher

Learn Check was also mentioned frequently as an easy function, even though it requires teachers to enter questions ahead of time. Teachers said the tool made it easy for them to assess students quickly and informally during lessons. More specifically, teachers reported that Learn Checks made it easy to identify difficult questions quickly and then to focus their instruction. It let teachers know when to move onto the next problem and, teachers said, was very helpful in reviewing homework. According to one teacher,

> *I think that the Learn Check has been the most helpful for me as a teacher. Because when I go over homework by using a Learn Check I'm not spending a lot of time on problems that most of the class knows how to do.… And if I feel like if I need to go talk to that one kid about 'Do you understand what's going on here?' Then I can but I don't have to waste class time answering that question. Because for the most part everybody got it. So I like that a lot.*

Teachers interviewed said that they used Activity Center the least because they had had the least amount of training on it and because it takes a lot of preparation on the teacher's part. Many teachers reported a lack of confidence in using Activity Center, saying "I'm not there yet" or "I need practice." One teacher stated, "I haven't had a chance to use it a lot. And most of the time when I used it something goes wrong and I don't know how to fix it. And the kids get really frustrated." This comment was representative of what many teachers said about Activity Center. At the same time, it appears that the more practice teachers had with using Activity Center in class, the easier it became for them, resulting in positive feedback from students and teachers. For the teachers who have used it, they discussed using it for teaching different topics. One teacher said,

> *I use it for transformation of quadratics and anything we can represent on the graph I can pretty much use it. Because they really enjoy Activity Center a lot more than any of the other things. So anytime I pull the Activity Center, they're excited for that…. And I think when you start and you challenge them, who can do it first, it becomes kind of more competition oriented. And they're laughing when they see way off and the kid will even be like, "That's me. I did it." And so they're all like "Oh, you forgot your x squared." And they're helping each other. So it makes the class more, it's not just me standing at the front talking and them listening. They get to really interact with each other and with me. That's what they like about it the best.*

I think that the Learn Check has been the most helpful for me as a teacher. Because when I go over homework by using a Learn Check I'm not spending a lot of time on problems that most of the class knows how to do.… And if I feel like if I need to go talk to that one kid about 'Do you understand what's going on here?' Then I can but I don't have to waste class time answering that question. Because for the most part everybody got it. So I like that a lot.

—Participating Teacher

Several teachers also mentioned positive benefits of using Screen Capture. Teachers said Screen Capture allowed them to spot easily challenging areas for students and allowed students to see where their mistakes are being made. One teacher described the benefits of Screen Capture this way:

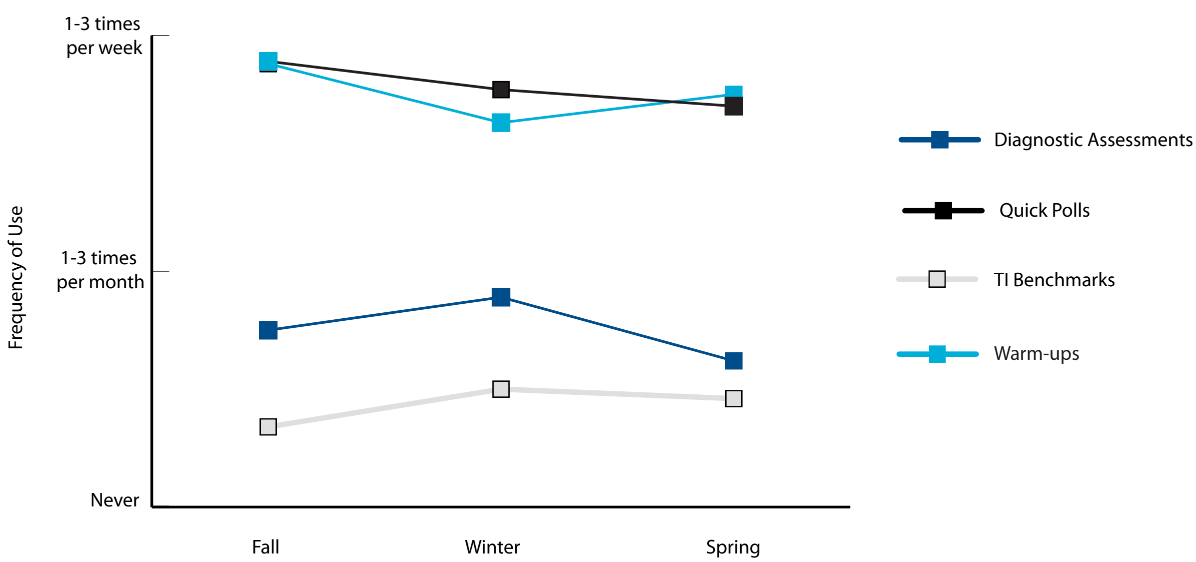
> *Then they see, like if they forget to put parenthesis around the negative number and get a different answer than somebody else then the other kids are, 'Oh well this is what you did wrong.' So it's reinforcing them realizing that's a mistake that's common. And it's helping that other child to learn how to do it.*

Use of Problems and Assessments Embedded in TI-Navigator™

A critical component of all technology-supported interventions is the content that programs provide to teachers. Indeed, it may be that the complete system of professional development, curricular materials, and technology is necessary for programs to achieve a positive impact on student achievement (Roschelle et al., 2007). MathForward™ provides all teachers with lesson plans and activities, as well as assessments they can use in their classes. The intent is to provide teachers with examples of powerful uses of TI-Navigator™ technologies that introduce or give students practice with core mathematics concepts.

For the most part, teachers used the TI-Navigator™ assessment functions more often than particular test questions provided with the program (Figure 15). Quick Poll and Warm-ups remain the more frequently used assessment tools; on average, teachers use each approximately 1.75 times per week. Teachers used the Diagnostic Assessments more often in winter (0.89 time per week) than in fall or spring (0.75 and 0.62 periods per week, respectively). The TI Benchmark assessments were least frequently used, but showed a slight increase in use from fall (0.34 periods per week) to winter (0.5 periods per week).

Figure 15. Use of TI-Provided Assessments in the Past Month



Source: Survey F11, W6, S12
$55 \leq n \leq 57$

Nearly all teachers interviewed reported that they made up their own problems for TI-Navigator™ tasks. Teachers primarily used other teachers/specialists as resources for problems, including colleagues at their school, their MathForward™ instructional coach, district support staff, and even teachers from other districts during training events. Teachers also drew from worksheets that were appropriate to the daily lesson and district curriculum because they focused on their state assessment and state standards.

Most teachers did not feel that the original CDs containing algebra lessons/activities were useful to them for several reasons. First and foremost, they are not aligned with their state standards. Second, files were not organized in a way that made it easy for teachers to identify the content of each file. One teacher summed it up this way:

> *They told us in the beginning we were going to have all these lessons and we could go on and find activities and we went on and nothing was organized at all, it was named all these weird files like 502J, and I'm like, "What does that mean?" So it took forever just to go through and look at them. Nothing was really aligned to [our state's] standards, so it was like not organized in any way that would be beneficial to us, and it was just very cumbersome to go and look for the activity.*

Although many found the lessons and activities not useful as they were written, some teachers modified them to fit their needs. For example one teacher stated, "At the very beginning they gave us Warm-ups and they were divided out. Number operations, different categories already set up for a day and my only issue was that it didn't fit everything that I was doing so I just selected and made my own new Warm-up out of their Warm-ups."

Some teachers interviewed did report using the Activities Exchange website and found lessons useful for their classroom. Teachers liked having the abundance of activities that were easily accessible to them. One teacher stated, "The TI website is really cool because you can search by type of problem that, you know, I want to do. A pre-algebra level geometry activity for grades five through eight, I can do a string search of those four things and they're going to give me all the activities that fit that." Another teacher talked about using the website during the teaching break, "I just look and I'll find lessons and those lessons that I'll try in class, and if they work, they work. If they don't, I try to adapt them for the following year, but it's a lot easier to plan during like spring break, Christmas break, and summer."

Instructional Strategies Teachers Use with TI-Navigator™

In this section, we discuss the instructional strategies teachers used with TI-Navigator™, as well as their reports of how their instruction has changed since introducing the technology into their classrooms.

Supporting Discussion of Mathematics Concepts

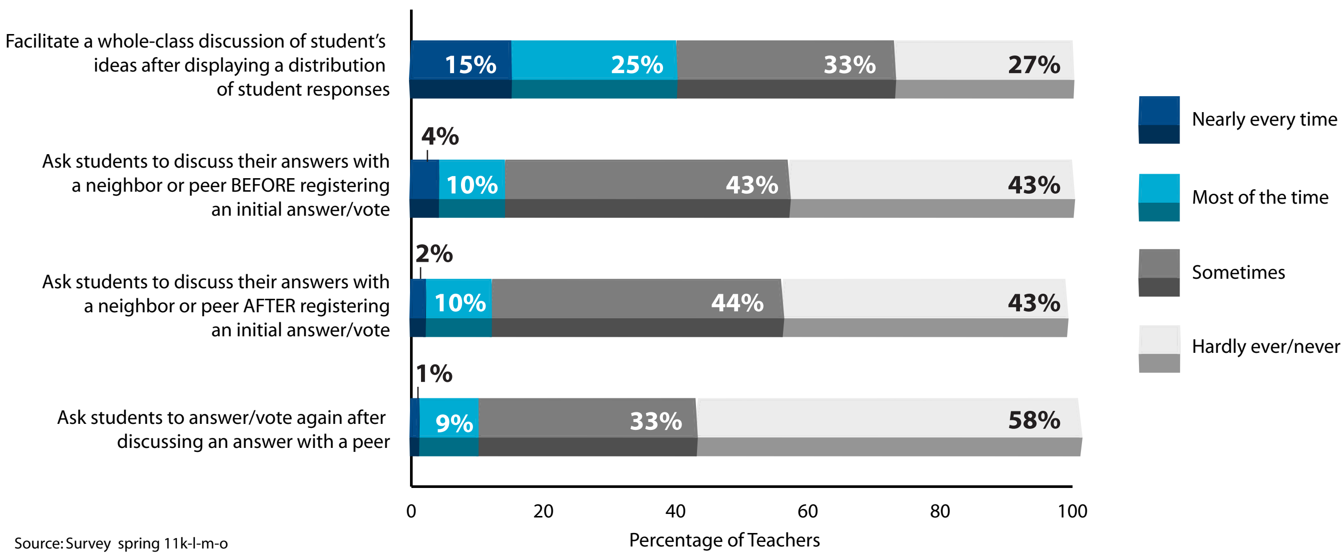
Key Finding

Teachers varied in the extent that they engaged students in extended discussion of their ideas. When they did engage students, most often discussion was part of whole-class instruction or review.

Orchestrating discussion in mathematics classrooms is at once one of the most difficult tasks and most important for learning (Blanton & Stylianou, 2008; O'Connor, 1994; O'Connor & Michaels, 1996). Discussion is difficult to orchestrate in part because it requires that student thinking be visible in participation. It is valuable and important because, through discussion, students can test and revise their ideas. TI-Navigator™ technology facilitates discussion of mathematics contexts by making it easy to make public any student's (or group of students') ideas, so that the class or some subgroup of students can discuss them.

Figure 16 describes the frequency of use of different teaching strategies in MathForward™ classes. The most commonly used strategy was facilitation of whole-class discussion of students' ideas after displaying a distribution of student responses, with 40% of teachers reporting doing it most or nearly every class. Less common activities that teachers reported engaging in at least sometimes included asking students to discuss their answers with a neighbor or peer before registering an initial answer or vote (57%), after registering an initial answer or vote (56%), and asking students to answer or vote again after discussing answer with a peer (43%).

Figure 16. Use of TI-Navigator™ to Foster Student Explanation and Discussion



Source: Survey spring 11k-l-m-o
$79 \le n \le 81$

In contrast to what teachers reported on the surveys, use of TI-Navigator™ to foster student explanation was a focus in only a small number of observations we conducted. Asking students to give reasons for a given answer was most common (see Table 11). Observers' holistic ratings indicated that there were about equal numbers of observed classes in which students simply stated answers without any explanation and in which students stated their answer and gave a thorough explanation using mathematical concepts and problem-solving strategies. There were no clear differences on these ratings for programs by implementation year.

Table 11. Proportion of Observed Activities when Teachers Fostered Discussion

	Percent (Number)	
	Some Focus in Teachers' Instruction	Major Focus in Teachers' Instruction
Asking students to give reasons for a given answer	29 (6)	24 (5)
Diagnosing students' conceptual or procedural error and reteaching a concept or procedure	24 (5)	14 (3)
Probing student responses for depth and clarity	19 (4)	14 (3)

Source: Structured Observation Protocol, Item 17
n = 21

The contrast between three observed teachers' use of TI-Navigator™ to focus instruction and discussion on mathematics reveals both the potential of the tool and the challenges teachers face in making the most of its capabilities.

In one class observed, the teacher led the students through a series of problems. First, the teacher wrote an equation on the board. Each student then had to select coordinates that were possible solutions to the equation and enter them into his/her calculator. The teacher then gathered the students' points and displayed them in a chart on a screen at the front of the class. Next the teacher switched to the graph view, where the calculator had plotted the students' points and drawn the curve of a function.

In this particular class, the teacher discussed the results and had the students think about whether or not they were accurate and why that was the case. For example, when the teacher first collected points from students, he noted immediately that everyone had submitted correct coordinates. He asked the students, "How can I look and tell that it looks good so fast?" The students responded by noting that the equation says that each of the y-coordinates is supposed to be twice the x-coordinate. When the teacher first switched from the chart to the graph, nothing was visible on the graph. The teacher asked the students, "How come I can't see anything?" He then used this scenario as an opportunity to talk about the domain and range for the graph. Using the graph as a visual, the teacher talked about the relationship between the numbers in the chart (the coordinate points) and the shape of the curve on the graph. As the class worked through each of the sample problems, the teacher went back to the four cases and drew prototypical graphs for each one. At every opportunity, the teacher emphasized the relationships between the multiple representations being used: equations, charts, and graphs. He talked explicitly about why certain equations would have graphs with certain shapes, falling in certain quadrants.

In a lesson on discriminants, another teacher opened the class by displaying a graph and asking students to reflect on what they could say about it. By starting out with an open-ended question, the teacher elicited a wide variety of responses from students. As students shared characteristics of the graph, the teacher probed on specific answers to guide the conversation to a deeper conceptual level.

After students described the graph in some detail, the teacher linked the discussion back to the main topic by asking, "Who can tell me what type of discriminant I have? Think of the options. I want to know what type of discriminant, positive or negative, perfect square or not." One student offered a guess, but admitted, "That was a complete guess, because it looks like a perfect parabola." Rather than abandoning the response and looking for a student who could provide a full explanation, the teacher probed the class to think about the relationship between the shape of the graph and the type of discriminant. This comment prompted one student to ask, "Aren't discriminants always going to be real, because they're going to go through the x-axis?" The teacher shepherded the discussion forward by encouraging the students to debate this conceptual issue with one another, asking, "Who wants to argue with this?" As students discussed the issue, the teacher continued to encourage students to elaborate their thoughts by asking students the "why" question.

In contrast, a third lesson on linear, quadratic, and exponential functions highlights a missed opportunity to use TI-Navigator™ to focus discussion and instruction on important concepts. The teacher began the lesson by passing out a series of reprints, with equations, graphs, and charts displayed randomly. The students cut up all the handouts so that they could group the representations into associated sets of three. The teacher instructed them to figure out which representations matched one another. The students were to enter either the equation or the coordinate points into the calculator and have the calculator draw the graph. The students then combed through their piles of graphs to find the one that looked like the one on the calculator screen. The teacher used Screen Capture to ensure that the students were "on track." The teacher also stopped the class momentarily to point out that they might have to adjust their range and domain to get the picture on the calculator to look like the one on their paper.

In this third class, the teacher used the calculator primarily to reduce the cognitive load from the students almost entirely and did not engage students in thinking more deeply about concepts. Students worked mostly on their own, and the teacher used the technology to monitor their compliance with the task. The assignment given made the task quite simple and required little of the students in the way of deeper conceptual thinking.

Use of TI-Navigator™ to Provide Feedback to Students and Adjust Instruction

Effective formative assessment requires providing students with feedback on how to improve and making adjustments to instruction on the basis of what is learned from assessments (Black & Wiliam, 1998). TI-Navigator™ technology facilitates both: Through the shared but anonymous displays, students can see immediately not only whether they got a problem right or wrong, but also whether their classmates did. They can, in this situation, feel less "alone" with

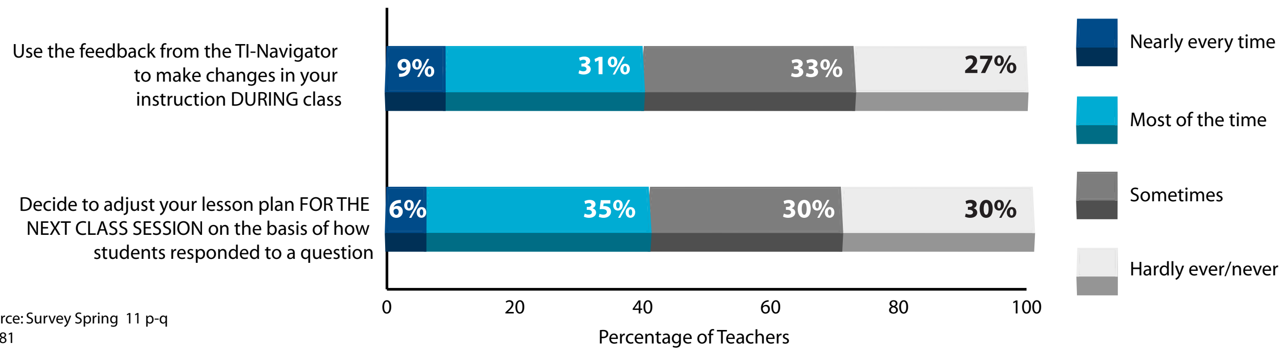
Key Finding

Most teachers did use the displays in their class so that students can see the distribution of responses to problems in class, and some used the data to speed up or slow down the pace of instruction.

respect to their difficulties in learning than they would without the display. In addition, MathForward™'s array of activities are provided with the intent of supplementing the teacher's own materials and extending learning opportunities in areas where students might be experiencing difficulties.

Survey data indicated that about two-fifths of teachers made adjustments to their instruction on the basis of what they learned from TI-Navigator™ assessment activities each time they used the system. About the same number of teachers made those adjustments during class as made them for the next class session (see Figure 17).

Figure 17. Use of TI-Navigator™ to Provide Feedback and Adjust Instruction



Source: Survey Spring 11 p-q
n = 81

The data from observations were consistent with the survey data relative to teachers' use of assessment data in class. In 7 of the 21 observations conducted, teachers adjusted instruction on the fly based on how well students understood the material being taught, as revealed by a Quick Poll or Learn Check. In all but four of the classes, teachers made at least some use of assessment data to provide feedback to students.

In the observed classes, Quick Poll and Learn Check were the favored methods of assessment, and teachers used the results most often to adjust the pace of their instruction. In particular, they used the data on what percentage of students got questions right to either move quickly past certain topics or to reteach problems most students were still having trouble understanding how to solve. Observers did note occasions when teachers appeared to ignore student results, even when many students did not solve a problem correctly. It may be that these teachers felt pressure to move on because of limited instructional time, but it is important to note that it is possible to use

TI-Navigator™ in ways that in fact do not support adjustments to instruction on the basis of student data, even though the tool is designed to help teachers to do so.

Teachers' Reported Changes to Instruction After Introducing TI-Navigator™

When asked in interviews about the kinds of changes they made to their instruction after introducing TI-Navigator™, the majority of teachers said it altered their questioning strategies. As a result of TI-Navigator™, they asked students more probing and in-depth questions. Furthermore, several teachers said that using the TI-Navigator™ to examine student responses enabled them to force students to become more reflective about their answers to questions. One teacher stated, "And now you could say, 'Why do you think this person got this wrong? What did they do to get this wrong?'" Another teacher stated that since she introduced TI-Navigator™,

> *I will start asking, like rather than just giving me the definition for the term, try to give me reasoning why you say this. Explain in your own words why it is or why it's not, giving a relationship, a contrast, and compare type of question.*

Teachers also reported that introducing TI-Navigator™ required them to change how they planned for lessons. Teachers acknowledged that TI-Navigator™ required more preparatory time to think about how to use the calculator to demonstrate concepts, about what questions to ask, and how to apply it to the real-world concepts. Despite more planning time, however, nearly all teachers felt the extra time was well spent. Several teachers stated that they could not imagine not using TI-Navigator™ in their classroom from this point on. One teacher said, "And TI did say when you start using this you're not going to want to go back to teaching without it, and I completely agree." Another teacher stated, "Basically, like if I ever had to leave, I would have to buy my own Navigator system because I don't know how I would teach without it."

IMPLEMENTATION QUALITY BY DISTRICT

In this section, we review the three levels of the implementation rubric and indicate each district's level on the rubric. The three levels used to characterize districts' and schools' implementation quality are shown in the sidebar.

Because data are missing at the school level, accurate assignments of each school's level of implementation quality cannot be made. Instead, each district's level of implementation quality is reported here. For four of the descriptors of implementation quality, data from the surveys and interviews are the basis for making assignments of districts (Table 12). To make assignments consistently, the research team used the preponderance of evidence rule often used in rubric scoring. Sources of evidence for the assignments include surveys, interviews, and classroom observations (in selected districts). A district was assigned to a category on the basis of where the preponderance or weight of evidence falls, using the descriptors of the rubric and data as a guide.

The data in Table 12 represent holistic ratings from multiple data sources; a more rigorous process needs to be developed in future years to assign districts and schools to different levels of implementation quality. The holistic approach was necessary, given that the rubric was developed after data

Levels of Implementation

1. **Congruent enactment:** The district or school is enacting MathForward™ in ways consistent with the intent of the program; adaptations to local contexts are not likely to undercut program goals.
2. **Transformed enactment:** The district or school is enacting MathForward™ in ways that change the intent of the program; the contexts constrain enactment in ways that are likely to undercut the program goals.
3. **Limited enactment:** The district or school is not enacting MathForward™ or is enacting fewer than half of the required components.

Table 12. Characterization of District Implementation Quality

	Dimension of Quality			
	Leadership	Allocation of Instructional Time	Use of TI-Navigator	Common Planning Time
Richardson ISD	Congruent	Congruent	Transformed	Congruent
Dallas ISD	Transformed	Congruent	Transformed	Congruent
Euclid City Schools	Congruent	Congruent	Congruent	Transformed
Palm Beach County School District	Congruent	Transformed	Transformed	Transformed
Brentwood Union School District	Limited	Congruent	Limited	Transformed
Canton Local School District (Summit-Stark)	Congruent	Congruent	Transformed	Transformed
Copley-Fairlawn City School District	Limited	Limited	Limited	Transformed
Jackson Local School District	Congruent	Congruent	Limited	Limited
Springfield Local School District	Congruent	Congruent	Congruent	Transformed
Hays Independent Schools	Transformed	Congruent	Limited	Transformed
Levittown Public Schools	Transformed	Congruent	Congruent	Limited

Source: Survey Items F22 & S30 (Leadership), Survey Items F16 and F17 (Allocation of Instructional Time), Survey Items S19 & S20 (Professional Development), Survey Items S10, S11, and W5 (Use of TI-Navigator), Survey Item S26 (School Support) collection had begun. In future years, a more rigorous process might involve the creation of a school portfolio or identification of common data that all schools could provide to TI or to the evaluator. Because of limitations in the data and the lack of transparency to districts themselves about how the rubric would be used, these data should not be used to make decisions about programs in these districts. Instead, the data are presented primarily as a means for program-wide reflection on which aspects of implementation might need greater attention.

As the table indicates, most districts' implementation was congruent with TI's intent for the program in all categories except for common planning time. More than half of the districts' implementation was congruent with respect to leadership as judged by teachers' reports of whether their principal had a strong vision for how MathForward™ would improve their school. Nine of 11 had implemented block scheduling in ways consistent with TI's model for the program, and in 6 of 11 districts, teachers frequently used different TI-Navigator™ functions in ways that supported high-quality instruction in mathematics. By contrast, in the category of common planning time, only 2 districts enacted common planning time as intended, using the time for other purposes. These findings suggest that greater effort may be needed in supporting effective use of common planning time and developing program leadership at MathForward™ schools.

Looking across categories, some districts stand out as having particularly strong implementations. Richardson ISD had the most "congruent" ratings; districts with three of four congruent ratings were: Dallas ISD, Euclid, Canton Local, and Springfield Local. The most problematic district implementations, from the standpoint of the rubric, were in Brentwood, Copley-Fairlawn, and Hays ISD. Calling these districts out in some ways is less important than noting that the different dimensions of the rubric appear to be interrelated. Strong leadership appears to be associated with better use of common planning time and instructional change; conversely, limited involvement of leaders, modified instructional blocks, and lack of support for collegial interaction were all linked to lower levels of implementation.

Quantitative analyses of the survey implementation data indicate a "district effect" for several key instructional variables. We ran several multilevel models in an effort to determine whether districts mattered, and indeed they do for breadth of TI-Navigator™ Use, the extent to which teachers ask students to explain or defend their ideas, and the degree to which teachers use data from TI-Navigator™ assessments to adjust their instruction. Except for this last dimension, where implementation year was related to adjustment of instruction (teachers whose districts are in later years of implementation adjusted more), we were unable to explain this effect with the quantitative models we ran. Nonetheless, the finding of a district effect suggests some important ways that the larger systemic context may matter to the success of the program.

Conclusions and Recommendations for Improving Implementation Quality

So far in its development of MathForward™, TI has brought its greatest strengths to designing a systemic mathematics reform program. TI's strengths are its ability to use a combination of professional and technical support to help teachers from a wide range of backgrounds integrate technology into mathematics instruction. MathForward™ has proven that TI can do that in the context of a district and school reform initiative, providing teachers with the coaching and technical resources they need to use TI-Navigator™ in the middle grades and in the early high school years. These are important capabilities for a company seeking to promote systemic reform; those capabilities distinguish TI from earlier reform efforts led by states in which professional learning was given little consideration (Smylie, 1996).

Further, there is evidence from the implementation evaluation that teachers in the program used a range of TI-Navigator™ functions and used them often. Although teachers tended to favor those functions that fit best within their modes of assessment and instruction, many over time and even in the first year utilized the unique capabilities of the system for promoting deep conceptual learning in mathematics. Those are significant accomplishments, since classroom network technology makes particularly high demands of teachers to orchestrate use and solve problems that arise. It is significant that most teachers were able to work through what could have been significant technical issues on their own and with the support of colleagues and students in their school. This level of usability suggests that the technology has the potential for broad scalability.

There are some significant opportunities for improvement in the program, both to enhance the process of planning and long-term sustainability within schools. Thus far, the strengths of the program are in setting up conditions of implementations over which a commercial company or other reform intermediary organization can have significant control, such as the provision of resources and professional development. At the same time, TI has been less successful in helping local districts identify ways that they can adapt the program to fit local realities and competing initiatives. The fact that many districts have modified blocks and common planning time as key supports for the program suggests that the image TI has for the program needs some revision.

Recommendations for Program Planning

One key recommendation for the program planning phase is to explore different models for how schools can set up and make the most of block scheduling. Schools may need to divide their block into separate sections, and teachers and principals need ways to think about how to organize instruction under conditions other than a single continuous block with the same group of students. What to do with the "second half" of the block is a struggle for many districts, and TI's MathForward™ program could become a leading provider of resources and time to help districts that are considering the program to devise a plan that fits with the overall goal of increasing quality instructional time in mathematics for students who most need it in order to close achievement gaps.

Second, we recommend that TI consider ways to foster teacher ownership over the process of change. Teacher ownership over the change process is essential to all kinds of systemic reform efforts; without it teachers' implementation can be minimal or transform designers' intent. Devising strategies to build ownership might reduce the number of teachers who knew little about what their school or district had committed them to implement. It might also increase the pressure they put on themselves to integrate TI-Navigator™ technology more frequently into their instruction.

Third, to support program planning, we recommend TI consider integrating more opportunities for regional off-campus meetings of MathForward™

Recommendations for Program Planning:

- Explore alternative models for block scheduling
- Require faculties to vote to be part of the program
- Integrate more opportunities for teachers to meet with other MathForward™-teachers

teachers to share ideas. At least one group of teachers in the program found such meetings more valuable than their own grade-level meetings. The group consisted of teachers from their same state, so they shared a common set of standards they were expected to teach. But more important, the time could be focused more intently on the program's strategies for instruction than would have been possible in the teachers' own departmental meetings. This was because the department consisted of numerous teachers who were not part of the program at all. Further, even when all teachers are in the program, common planning meetings can rarely be dedicated to a single program such as MathForward™. It is possible to imagine providing teachers who do share common planning time with protocols to guide discussions of lessons or samples of student work, but TI cannot expect that schools will use this time to engage in extensive development of Activity Center lessons or activities, as had been originally conceived.

Recommendation for Implementation Support:

- Develop professional development resources related to teaching with TI-Navigator™

Recommendations for Implementation Support

In terms of implementation support, our main recommendation is to develop additional professional development activities and resources to help teachers integrate more cognitively demanding strategies into their instruction. We observed teachers use TI-Navigator™ without engaging student thinking at all; these and other prospective teachers in the program may need assistance in developing ways to orchestrate discussions of student ideas and thinking in ways that exploit the technology more effectively. Therefore, we recommend that more professional development resources be dedicated to helping teachers make use of student data to support student explanation and justification of their ideas. The content-related professional development activities could support these activities as well, by incorporating examples of cognitively challenging problems for teachers to solve that teachers in turn could assign to students.

Recommendations for Scalability and Sustainability:

- Identify strategies for building capacity for systemic reform
- Create a vision for how districts will sustain the program on their own

Recommendations for Scalability and Sustainability

Finally, with respect to program scalability and sustainability, we see the need for TI to grapple with two questions that intermediary organizations (whether they are states, nonprofit organizations, or commercial entities) must all address to grow programs: (1) How will TI build its capacity for systemic reform in the coming years? and (2) What is TI's image of how schools and districts themselves will sustain the program with limited TI assistance? In addressing the first question, a fundamental challenge for the company is to develop people with skills that go beyond providing individual teachers and schools with assistance. Needed are people skilled in spanning organizational boundaries, identifying productive adaptations of the program to local context, and managing large numbers of local coaches. In addressing the second question, TI needs to engage more with the problem of "ownership" and develop strategies that build buy-in at a higher level and from a broader constituency at the planning phases than it has done so far.

REFERENCES

Alexander, C., & Stroup, W. (2006). *Richardson math project final report: Math TAKS* results. Austin, TX: University of Texas at Austin.

Ball, D. L., & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (Ed.), *Multiple perspectives on the teaching and learning of mathematics* (Vol. 83-104). Westport, CT: Ablex.

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education*, 5(1), 7-74.

Blanton, M. L., & Stylianou, D. A. (2008, March). C*hanging participation and identity through instructional scaffolding that promotes transactive discussion.* Paper presented at the Annual Meeting of the American Educational Research Association, New York, NY.

Blumenfeld, P., Fishman, B. J., Krajcik, J., Marx, R. W., & Soloway, E. (2000). Creating usable innovations in systemic reform: Scaling up technology-embedded project-based science in urban schools. *Educational Psychologist,* 35(3), 149-164.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research,* 65, 245-281.

Desimone, L. M. (2002). How can comprehensive school reform models be successfully implemented? *Review of Educational Research,* 72(1), 433-479.

Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis,* 24(2), 81-112.

Elmore, R. F. (1996). Getting to scale with good educational practice. *Harvard Educational Review,* 66, 1-26.

Elmore, R. F., Peterson, P. L., & McCarthey, S. J. (1996). *Restructuring in the classroom: Teaching, learning, and school organization.* San Francisco: Jossey-Bass.

Fishman, B. J., & Krajcik, J. (2003). What does it mean to create sustainable science curriculum innovations? A commentary. *Science Education,* 87(4), 564-573.

Garet, M. S., Porter, A. C., Desimone, L. M., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal,* 38(4), 915-945.

Hegedus, S. J., & Penuel, W. R. (2008). Studying new forms of participation and identity in mathematics classrooms with integrated communication and representational infrastructures. E*ducational Studies of Mathematics,* 68(2), 171-184.

Johnson, S. M. (1990). *Teachers at work: Achieving success in our schools.* New York: Basic Books.

Jussim, L., & Eccles, J. S. (1992). Teacher expectations: Construction and reflection of student achievement. *Journal of Personality and Social Psychology,* 63(6), 947-961.

Kaput, J., & Hegedus, S. (2002). *Exploiting classroom connectivity by aggregating student constructions to create new learning opportunities.* Paper presented at the 26th Conference of the International Group for the Psychology of Mathematics Education, Norwich, UK.

Knapp, M. S. (1997). Between systemic reforms and the mathematics and science classroom: The dynamics of innovation, implementation, and professional learning. *Review of Educational Research,* 76(2), 227-266.

Newhouse, C. P., & Rennie, L. (2001). A longitudinal study of the use of student-owned portable computers in a secondary school. *Computers & Education,* 36(3), 223-243.

O'Connor, M. C. (1994). Managing the intermental: Classroom group discussion and the social context of learning. In D. I. Slobin, J. Kyratzis, & J. Guo (Eds.), *Social interaction, social context and languages: Essays in honor of Susan Ervin-Tripp.* Hillsdale, NJ: Lawrence Erlbaum Assocication.

O'Connor, M. C., & Michaels, S. (1996). Shifting participant frameworks: Orchestrating thinking practices in group discussions. In D. Hicks (Ed.), *Discourse, learning, and schooling* (pp. 63-103). New York: Cambridge University Press.

O'Donnell, R. J., & White, G. P. (2005). Within the accountability era: Principals' instructional leadership behaviors and student achievement. *NASSP Bulletin,* 89, 56-71.

Penuel, W. R., Fishman, B. J., Gallagher, L. P., Korbak, C., & Lopez-Prado, B. (2008). The mediating role of coherence in curriculum implementation. In *Proceedings of the 8th International Conference of the Learning Sciences.* Utrecht, the Netherlands: Erlbaum.

Penuel, W. R., Roschelle, J., & Abrahamson, A. L. (2005). Research on classroom networks for whole-class activities. In *Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education* (pp. 222-229). Los Alamitos, CA: IEEE.

Roschelle, J., Penuel, W. R., & Abrahamson, A. L. (2004). The networked classroom. *Educational Leadership,* 61(5), 50-54.

Roschelle, J., Tatar, D., Shechtman, N., Hegedus, S., Hopkins, B., Knudsen, J., et al. (2007). *Scaling up SimCalc Project: Can a technology enhanced curriculum improve student learning of important mathematics?* Menlo Park, CA: SRI International.

Rowan, B., Chiang, F., & Miller, R. J. (1997). Using research on employees' performance to study the effects of teachers on student achievement. *Sociology of Education,* 70, 256-284.

Rowan, B., Correnti, R., & Miller, R. J. (2002). What large-scale, survey research tells us about teacher effects on student achievement: Insights from the Prospects Study of Elementary Schools. *Teachers College Record,* 104(8), 1525-1567.

Sherman, D., Kleiman, G., & Peterson, K. (2004). *Technology and teaching children to read.*

Silvernail, D. L., & Harris, W. J. (2003). *The Maine Learning Technology Initiative teacher, student, and school perspectives: Mid-year evaluation report*. Portland, ME: Maine Education Policy Research Institute, University of Southern Maine.

Sizer, T. R. (1984). *Horace's compromise: The dilemma of the American high school*. Boston: Houghton-Mifflin.

Smylie, M. A. (1996). From bureaucratic control to building human capital: The importance of teacher learning in education reform. *Educational Researcher,* 25(9), 9-11.

Spillane, J. P., & Jennings, N. E. (1997). Aligned instructional policy and ambitious pedagogy: Exploring instructional reform from the classroom perspective. *Teachers College Record,* 98, 449-481.

Stroup, W., Pham, V., & Alexander, C. (2007). *Richardson Math Project*. Austin, TX: University of Texas at Austin.

Supovitz, J. A. (2007). *The case for district-based reform: Leading, building, and sustaining school improvement*. Cambridge, MA: Harvard University Press.

Windschitl, M., & Sahl, K. (2002). Tracing teachers' use of technology in a laptop computer school: The interplay of teacher beliefs, social dynamics, and institutional culture. *American Educational Research Journal,* 39(1), 165-205.

Winick, M., & Lewis, J. (2006). Y*ear 1 assessment of the RISD-TI intervention model*. Redlands, CA: Winick & Lewis Research, LLC.

Winick, M., & Lewis, J. (2007a). *Texas Instruments MathForward intervention 2007 overall year end report.* Dallas, TX: Texas Instruments.

Winick, M., & Lewis, J. (2007b). *TI-DISD MathForward intervention 2007 year end report.* Dallas, TX: Texas Instruments.

Winick, M., & Lewis, J. (2007c). *TI-Euclid City School District MathForward intervention 2007 year end report.* Dallas, TX: Texas Instruments.

Winick, M., & Lewis, J. (2007d). *Year 2 assessment of MathForward in RISD.* Redlands, CA: Winick & Lewis, LLC.

APPENDIXES

APPENDIX A

Implementation Quality Rubric

	DISTRICT LEVEL	SCHOOL LEVEL
Congruent Enactment The district or school is enacting MathForward in ways consistent with the intent of the program; adaptations to local contexts are not likely to undercut program goals	A district champion supports the program and actively monitors its implementation. Nearly all or all schools allocate a continuous block of 100 minutes per day for MF. The district provides for release time and/or payment for teachers to participate in professional development. Teachers' average use of Navigator is 2-3 times per week; when teachers use it, they use it for feedback most of the time and engage students in discussions about their ideas. There are 3-4 times per year set aside for district MF teachers to meet to discuss their implementation. At least 75 percent of teachers participated in the evaluation, as measured by survey response rate.	School allocates a continuous block of 100 minutes per day for MF. All teachers participate in initial training and report engage with coaches who observe or teach in their classrooms. Most teachers use Navigator 2 to 3 days per week and use Activity Center or Screen Capture once per week. When using Navigator, teachers report using it to provide feedback and adjust instruction "most of the time." When using Navigator, teachers ask students to explain their reasoning and foster extended discussions about problems. Teachers reported using common planning period to discuss multiple (>5) aspects of MF. Principal support for the program is strong.

	DISTRICT LEVEL	SCHOOL LEVEL
Transformed Enactment The district or school is enacting MathForward in ways that change the intent of the program; the contexts constrain enactment in ways that are likely to undercut the program goals	A district champion supports the program but does not actively monitor implementation. Some of the schools allocate a continuous block of 100 minutes per day for MF; some have transformed the idea of a continuous block while still adding instructional minutes. The district provides for release time to participate in professional development, but fewer than are requested by teachers or the MF coach. Teachers' average use of Navigator is 1 time per week; when teachers use it, they use it for feedback sometimes and elicit students' ideas as part of classroom instruction. There are 1-2 times per year set aside for district math teachers to meet to discuss; MF may be part of the discussion, but not necessarily. Between 50 and 75 percent of teachers participated in the evaluation, as measured by survey response rate.	School allocates significant additional time for mathematics in MF classrooms, but not as part of a continuous block. All teachers participate in initial training and some interactions with coaches outside of training. Most teachers use Navigator 1 day per week and use Activity Center or Screen Capture less than once per week. When using Navigator, teachers report using it to provide feedback and adjust instruction "sometimes" or "most of the time." When using Navigator, teachers ask students to explain their reasoning but do not foster extended discussions about problems. Teachers reported using common planning period to discuss a few (2-5) aspects of MF. Principal support for the program is strong.

	DISTRICT LEVEL	SCHOOL LEVEL
Limited Enactment The district or school is not enacting MathForward or is enacting fewer than half of the required components.	There is no clear district champion for the program. Half or more of the schools have not created continuous blocks of 100 minutes of mathematics for MF participants. The district does not provide for release time to participate in professional development. Teachers' average use of Navigator is 0-0.9 times per week; when teachers use it, they rarely use it for feedback most of the time and do not engage students in discussions about their ideas. The district does not provide time for its math teachers to meet. Less than 50 percent of teachers participated in the evaluation, as measured by survey response rate.	School changes to instructional time are minimal. Most teachers participate in initial training but interactions with coaches outside of training are limited. Most teachers hardly ever use Navigator and do not use Activity Center or Screen Capture. When using Navigator, teachers report using it to provide feedback and adjust instruction "sometimes" or "hardly ever/never." When using Navigator, teachers neither ask students to explain their reasoning nor foster extended discussions about problems. Teachers reported using common planning period to discuss 1 or fewer aspects of MF. Principal support for the program is strong.

APPENDIX B

MathForward™ Teacher Survey - May

1. With how many different classes are you implementing the Power Block?

- ☐ One class
- ☐ 2 or 3 classes
- ☐ 4 classes
- ☐ More than 4 classes

2. What grade level do you currently teach using the MathForward curriculum? Mark all that apply.

- ☐ Grade 6
- ☐ Grade 7
- ☐ Grade 8
- ☐ Grade 9

3. Which term best describes the MathForward course you are teaching? Mark all that apply.

- ☐ Elementary math
- ☐ Middle school math
- ☐ Pre-algebra
- ☐ Algebra
- ☐ Geometry
- ☐ Integrated math
- ☐ Advanced math

4. Which of the following best characterizes your target class? Mark all that apply.

- ☐ Average-achieving students, compared to the rest of the students in that grade level
- ☐ Low-achieving students, compared to the rest of the students in that grade level
- ☐ High-achieving students, compared to the rest of the students in that grade level

5. How many hours of mathematics instruction do students in your target class receive in a typical week?

- ☐ Less than 3 hours
- ☐ At least 3 hours, but less than 5 hours
- ☐ At least 5 hours, but less than 7 hours
- ☐ 7 or more hours

6. On what kind of schedule does your target class meet?

- ☐ Daily
- ☐ Block or rotating schedule
- ☐ Other

7. How long is your daily target class?

- ☐ Less than 60 minutes
- ☐ 60-79 minutes
- ☐ 80-99 minutes
- ☐ 100 minutes or longer

8. How frequently did you implement a 100-minute Power Block last week?

- ☐ Not at all
- ☐ Part of a block (less than 100 minutes)
- ☐ Once
- ☐ More than once

9. How much time did your students spend engaged in the following activities during the Power Block last week?

	0-10 minutes	11-15 minutes	16-30 minutes	31-40 minutes	41-50 minutes	51-60 minutes
a) Doing warm-up problems	☐	☐	☐	☐	☐	☐
b) Using district curriculum materials	☐	☐	☐	☐	☐	☐
c) Using TI-provided curriculum materials	☐	☐	☐	☐	☐	☐
d) Using teacher-created TI Navigator/calculator activities	☐	☐	☐	☐	☐	☐

10. In how many different class periods did you use the following tools in the TI Navigator with your target class last week?

	Not at all	1 period	2 periods	3 periods	4 periods	5 or more periods
a) Activity Center (Lead interactive class activities involving lists, graphs, points, and equations)	☐	☐	☐	☐	☐	☐
b) Quick Poll (Send polls to your students, receive their responses, and review poll results)	☐	☐	☐	☐	☐	☐
c) Screen Capture (Capture and view your students' calculator screens)	☐	☐	☐	☐	☐	☐
d) Class Analysis (Create, distribute, and analyze educational content)	☐	☐	☐	☐	☐	☐
e) App and OS Transfer (Transfer TI Graphing Calculator Operating Systems (OS) and Applications (Apps) to students' calculators)	☐	☐	☐	☐	☐	☐
f) Transfer Tools (Send, collect, and delete data files on your students' calculators using multiple applications)	☐	☐	☐	☐	☐	☐
g) Using calculator applications to teach	☐	☐	☐	☐	☐	☐

11. Using TI Navigator, how often did you do the following things as part of mathematics instruction last week?

	Hardly ever/never	Sometimes	Most of the time	Nearly every time
a) Collect homework or other assignments	☐	☐	☐	☐
b) Send problems or learning materials to students (e.g., apps, models, forms)	☐	☐	☐	☐
c) Look at screen shots of a student device on your computer	☐	☐	☐	☐
d) Display calculator screen shots for the class to view	☐	☐	☐	☐
e) Display a distribution of student responses to a question for all to see	☐	☐	☐	☐
f) Hide the distribution of student responses from students	☐	☐	☐	☐
g) Ask students to identify themselves to the whole class as answering a in a particular way	☐	☐	☐	☐
h) Prepare ahead of time the questions you will ask students using the TI Navigator	☐	☐	☐	☐
i) Ask students to use the system to answer a multiple-choice question at the beginning of class, before beginning the day's lesson	☐	☐	☐	☐
j) Ask students to use the system to answer a multiple-choice question in the middle of class, in the midst of the day's lesson	☐	☐	☐	☐
k) Ask students to discuss their answers with a neighbor or peer BEFORE registering an initial answer/vote	☐	☐	☐	☐
l) Ask students to discuss their answers with a neighbor or peer AFTER registering an initial answer/vote	☐	☐	☐	☐
m) Ask students to answer/vote again after discussing an answer with a peer	☐	☐	☐	☐
n) Ask students to answer/vote again after presenting an explanation of the idea or concept you are testing	☐	☐	☐	☐
o) Facilitate a whole-class discussion of students' ideas after displaying a distribution of student responses	☐	☐	☐	☐
p) Use the feedback from the TI Navigator to make changes in your instruction DURING class	☐	☐	☐	☐
q) Decide to adjust your lesson plan FOR THE NEXT CLASS SESSION on the basis of how students responded to a question	☐	☐	☐	☐

12. Indicate how often you used each of the following TI Navigator assessments when assessing students in your target class last MONTH.

	Never	1-3 times per month	1-3 times per week	4-5 times per week
a) Diagnostic assessments (assessment of students' background experiences, skills, and misconceptions)	☐	☐	☐	☐
b) Quick Polls (assessment of students' current level of understanding of concept being taught)	☐	☐	☐	☐
c) TI benchmarks (summative assessment of students' understanding compared with goals they were expected to achieve)	☐	☐	☐	☐
d) Warm-ups (short assessments of student progress in mastering national math standards)	☐	☐	☐	☐

13. Indicate the extent to which you agree with each of the following:

	Strongly disagree	Disagree	Agree	Strongly Agree	Unsure
a) Our unit diagnostics help me tailor instruction to meet student needs.	☐	☐	☐	☐	☐
b) The increased number of benchmarks has helped me improve instruction.	☐	☐	☐	☐	☐
c) The more immediate availability of benchmark data has helped me improve instruction.	☐	☐	☐	☐	☐
d) The feedback I receive on student learning is based upon the TI benchmark test data.	☐	☐	☐	☐	☐
e) The use of real-time feedback has accelerated learning in my class	☐	☐	☐	☐	☐
f) The added focus on testing often interferes with my curricular goals	☐	☐	☐	☐	☐
g) The added time required to collect benchmark data is worthwhile	☐	☐	☐	☐	☐
h) I am able to modify instructional strategies for individual students based on real time data collected through the TI Navigator.	☐	☐	☐	☐	☐

14. In how many different in-class assignments did your students do the following things as part of mathematics instruction last week?

	Not at all	1 or 2 assignments	3 or 4 assignments	5 or 6 assignments	In more than 6 assignments
a) Practice basic math facts (e.g., addition, subtraction, multiplication, and division)	☐	☐	☐	☐	☐
b) Read or interpret charts, tables, or graphs	☐	☐	☐	☐	☐
c) Make charts tables, or graphs	☐	☐	☐	☐	☐
d) Solve problems that have more than one correct answer	☐	☐	☐	☐	☐
e) Solve problems in which students practice applying a method they have been taught	☐	☐	☐	☐	☐
f) Solve problems in which students have to figure out what method to use to solve them	☐	☐	☐	☐	☐
g) Describe the procedure or algorithm students used to solve a problem	☐	☐	☐	☐	☐
h) Explain why a procedure or algorithm students used worked to solve a problem	☐	☐	☐	☐	☐
i) Prove that a particular method for solving a problem is valid	☐	☐	☐	☐	☐
j) Analyze similarities or differences among methods and types of problems	☐	☐	☐	☐	☐

15. How much emphasis did you place on the following concepts in your mathematics instruction last week?

	No emphasis (accounted for no instruct-ional time)	Slight emphasis (accounted for 25% of instructional time)	Moderate emphasis (accounted for 25-33% of instructional time)	Sustained emphasis (accounted for more than 33% of instructional time)
a) Number sense, properties, relationships	☐	☐	☐	☐
b) Operations	☐	☐	☐	☐
c) Measurement and use of measuring instruments	☐	☐	☐	☐
d) Algebra or algebraic concepts	☐	☐	☐	☐
e) Geometry or geometric concepts	☐	☐	☐	☐
f) Data analysis, probability, statistics	☐	☐	☐	☐

16. Rate the extent to which you agree or disagree with the following:

	Strongly disagree	Disagree	Agree	Strongly Agree	Unsure
a) The Power Block has made a real difference in how students approach difficult problems.	☐	☐	☐	☐	☐
b) The Power Block has increased my students' confidence in mathematics.	☐	☐	☐	☐	☐
c) I have noticed that the use of TI Technology has allowed students to understand concepts more quickly.	☐	☐	☐	☐	☐
d) I know just as much about student understanding without the TI Navigator as I do with it.	☐	☐	☐	☐	☐
e) Doing activities with the TI Calculator/TI Navigator in class helps students get a better understanding of concepts	☐	☐	☐	☐	☐
f) By using TI technology, I have more timely information about what students know.	☐	☐	☐	☐	☐

17. Which of the following TI Navigator activities did you engage in during any of the MathForward professional development workshops? Mark all that apply.

	No	Yes
a) Participated in a small group discussion related to TI Navigator	☐	☐
b) Wrote reflections in a notebook about TI Navigator	☐	☐
c) Practiced using TI Navigator	☐	☐
d) Engaged in a TI Navigator learning activity	☐	☐
e) None of the above	☐	☐

18. Rate the extent to which the following were a barrier to your use of MathForward:

	Not a barrier	A minor barrier	A major barrier
a) Lack of or insufficient access to TI Navigator equipment	☐	☐	☐
b) Lack of or insufficient access to TI Navigator-compatible calculators for students	☐	☐	☐
c) Unreliable hardware	☐	☐	☐
d) Unreliable or faulty connections between system tools	☐	☐	☐
e) Confusing software needed to use system tools	☐	☐	☐

19. What kind of feedback or guidance have you gotten from Implementation Coaches or others since starting MathForward? Mark all that apply.

	No	Yes
a) Practiced teaching with TI Navigator under simulated conditions, with feedback	☐	☐
b) Received coaching or mentoring during a formal workshop	☐	☐
c) Communicated with the coach concerning classroom implementation	☐	☐
d) Reviewed student work with coach and/or other MathForward teachers	☐	☐
e) Co-taught a lesson in your classroom	☐	☐
f) Modeled a lesson in your classroom	☐	☐
g) Observed and reflected on a lesson you taught	☐	☐

20. How many days did you attend any FOLLOW UP workshops with a TI instructor or Implementation Coach thus far?

- ☐ None at all
- ☐ 1-2 days
- ☐ 3-4 days
- ☐ 5-6 days
- ☐ More than 6 days

21. How many days did you attend MATH CONTENT workshops with a mathematician thus far?

- ☐ None at all
- ☐ 1-2 days
- ☐ 3-4 days
- ☐ 5-6 days
- ☐ More than 6 days

22. If you attended the CONTENT workshops, please rate the extent to which you agree or disagree with the following: Content Professional Development Workshops have provided opportunities for me to learn more about:

	Strongly disagree	Disagree	Uncertain	Agree	Strongly Agree	I have not attended a content PD workshop
a) Applying and adapting appropriate strategies to solve problems in each of the strands of mathematics: Number sense and Operations, Algebraic Thinking, Geometry and Measurement, Probability and Statistics	☐	☐	☐	☐	☐	☐
b) Solving problems that arise in mathematics and those involving mathematics in other contexts	☐	☐	☐	☐	☐	☐
c) Building new mathematical knowledge through problem solving	☐	☐	☐	☐	☐	☐
d) Monitoring and reflecting on the process of mathematical problem solving	☐	☐	☐	☐	☐	☐
e) Recognizing and applying mathematics in contexts outside of mathematics	☐	☐	☐	☐	☐	☐
f) Recognizing and using connections among mathematical ideas	☐	☐	☐	☐	☐	☐
g) How to use design assessment tools	☐	☐	☐	☐	☐	☐

23. Rate the extent to which you agree or disagree with the following: Content Professional Development Workshops have provided opportunities for me to learn strategies in the following areas:

	Strongly disagree	Disagree	Agree	Strongly Agree	Unsure
a) Number sense and operations	☐	☐	☐	☐	☐
b) Geometry and measurement	☐	☐	☐	☐	☐
c) Algebraic reasoning	☐	☐	☐	☐	☐
d) Probability and statistics	☐	☐	☐	☐	☐

24. Rate the extent to which you agree or disagree with the following. Professional development workshops related to MathForward helped me:

	Strongly disagree	Disagree	Agree	Strongly Agree	Unsure
a) Develop a better understanding of curriculum standards	☐	☐	☐	☐	☐
b) Use more challenging curriculum materials	☐	☐	☐	☐	☐
c) Increase my expectations for all students	☐	☐	☐	☐	☐
d) Increase my content and pedagogical content knowledge	☐	☐	☐	☐	☐
e) Spread innovative practices from PowerBlock to other lessons	☐	☐	☐	☐	☐

25. How often did you meet with your MathForward coach last month?

☐ Not at all
☐ 1-2 days
☐ 3-4 days
☐ 5-6 days
☐ More than 6 days

26. How many common planning periods did you have last month that were dedicated to the MathForward Program?

☐ None
☐ 1 period
☐ 2 periods
☐ 3 periods
☐ 4 periods
☐ 5 or more periods

27. Which of the following did you do during common planning time for MathForward last month? Mark all that apply.

	No	Yes
a) Worked together to design lessons that align with the district course of study	☐	☐
b) Examined student work	☐	☐
c) Individual teachers demonstrated lessons to the team (taught them as if part of a class)	☐	☐
d) A team choose a specific topic to study in depth and discussed research articles from journals	☐	☐
e) Analyzed data from classroom assessments	☐	☐
f) Discussed existing Activity Center activities	☐	☐
g) Developed new Activity Center activities	☐	☐
h) Discussed how to ensure regular positive communication with parents	☐	☐
i) Discussed which Power Block activities worked well with students	☐	☐
j) Discussed how to organize group or collaborative learning activities during PowerBlock	☐	☐

28. Think about your MOST advanced mathematics students. Do these students receive mathematics instruction that differs in any of the following ways from the instruction provided to your AVERAGE mathematics students?

	No	Yes
a) I set different achievement standards for these students.	☐	☐
b) I supplement the regular course curriculum with additional materials for these students.	☐	☐
c) I have these students engage in different classroom activities.	☐	☐
d) I use a different set of methods in teaching these students.	☐	☐
e) I pace my teaching differently for these students.	☐	☐

29. Rate the extent to which you agree with each of the following:

	Strongly disagree	Disagree	Agree	Strongly Agree	Unsure
a) I am responsible for students' high achievement in mathematics.	☐	☐	☐	☐	☐
b) Different mathematics teaching methods can affect a student's achievement.	☐	☐	☐	☐	☐
c) Students' poor attitudes towards mathematics reduce their academic success.	☐	☐	☐	☐	☐
d) Students' mathematics success or failure is due to factors beyond me.	☐	☐	☐	☐	☐
e) Students are incapable of meeting the learner standards in mathematics.	☐	☐	☐	☐	☐
f) I change my teaching approach if students are not doing well in mathematics.	☐	☐	☐	☐	☐

30. Mark the extent to which you disagree or agree with the following. The principal at this school:

	Strongly disagree	Disagree	Agree	Strongly Agree	Unsure
a) Makes clear to the staff his or her expectations for meeting the goals of MathForward	☐	☐	☐	☐	☐
b) Communicates a clear vision for MathForward in our school	☐	☐	☐	☐	☐
c) Sets high standards for teaching mathematics	☐	☐	☐	☐	☐
d) Understands how children learn mathematics	☐	☐	☐	☐	☐
e) Carefully tracks student progress in MathForward classrooms	☐	☐	☐	☐	☐
f) Pushes students and teachers to communicate regularly with parents about MathForward	☐	☐	☐	☐	☐

31. Please tell us your name. We will use this information internally; it will never be reported or released.
[text entry]

32. Please tell us the name of the school for which you are responding.
[text entry]

APPENDIX C

Teacher Interview Protocol

Date	______________________	Name	______________________
School	______________________	Title/ Position	______________________
	______________________	Grade(s) Taught	______________________

Overarching research questions:

- Is MF an isolated program or is it fully integrated into school curriculum?
- Is MF supported by the school district and to what extent?
- What is the level of investment at schools? Are teachers motivated or interested in using MF?
- What are the barriers and/or success factors for implementation?

A. Relative Usability and Value of TI-Navigator Functions

1. How would you characterize your use of Navigator in the classroom?
   Probe: How frequently do you use Navigator? Do you tend to use Navigator during a particular part of class (e.g., for warm-up activities)? Do you use Navigator more in some classes than in others? If so, what do you think accounts for that difference?

2. Of all the things Navigator can do (e.g., Quick Poll, Screen Capture, Activity Center), which is the easiest for you to use with students? Why is that function easy to use?

3. Which function is the hardest for you to use with students? Why is that function hard to use?

4. What do you value most about having Navigator in the classroom?

5. What do students value the most?

B. Technology Setups and Difficulties

6. What kinds of problems have arisen with the Navigator technology during set-up and use? How often do the problems occur?

NOTES: Wires, laptop recognizing hub, connections, changing battery, freezing interface, tech breakdown

7. How easy is it for you to troubleshoot problems that arise? What do you do when there are problems? Just switch activities?

Probe: Do you ever rely on students to help troubleshoot problems you can't solve on your own? What other resources can you rely on for assistance in remedying technology problems?

NOTES: Does training include technical troubleshooting? Do they have technical FAQs?

8. Have any difficulties arisen that require you to call for technical assistance? How readily available is that kind of assistance?

NOTES: Cite two instances/ please describe

C. Curricular Materials and Assessments

9. What are the primary sources for problems you assign when using TI-Navigator?
   Probe: district textbook? special curriculum? TI materials?

NOTES: Designed yourself or by other teachers? Make up activities on the fly or beforehand? Get them from internet?

10. To what extent are the TI-provided materials and assessments useful to you in your teaching?
    Probe: If the materials are not useful, what would make them more useful?

NOTES: Any weak spots in the TI curriculum/materials? Sweet spots?

D. Structural Components of the MathForward Program

11. How are the block schedules structured at your school?
    Probe: How long is a block schedule class? How often do they occur? How many of your classes use block schedule (i.e., is it all classes or just MathForward classes)? How useful do you find the block schedule?

NOTES: Some have "blocks" but 60 min, not 100. Total math hour/min per week? Daily block or every other day? Split block?

12. How is the common planning time functioning at your school?
    Probe: Was the common planning time newly implemented when you adopted MathForward? How frequently do you have a common planning time? To what extent do you use that time for planning MathForward activities in particular? How useful do you find the common planning time?

NOTES: Be skeptical. What amount of this time is really dedicated to MathForward as opposed to cross-subject time?

E. Changes in Student Participation over Time

13. When you first introduced TI-Navigator this year, how did students respond? Did particular groups of students respond differently?
    Probe: Was there excitement or resistance? Were there differences between high-achieving and low-achieving students (high or low participating students?)?

    NOTES: Effect on who used to/now participates. Smart kids may be less enthused because Navigator levels the playing field (equal participation)

14. What adjustments, if any, did you make in your teaching after introducing TI-Navigator, either in relation to using Navigator, or more generally?

    NOTES: Way they teach, effects on planning (kinds of problems, distractions). Get at any change in the level of challenge. Has the planning for class changed?

15. Was there a moment or time when you noticed TI-Navigator use seemed to have changed the dynamic in the classroom (e.g., how students were participating, how you interacted with students)? If so, what was the change that occurred? When did that change happen (ongoing? trajectory of change)?

NOTE: If time allows, continue with the final two sections.

F. School & District Supports

16. What are the supports that are available to you to help you learn Navigator and implement Navigator activities in the classroom?
    For each, probe: Who provides the support? When is the support provided (on what schedule, etc.)? How useful do you find the support?

17. Do you feel that you receive adequate support from the school leadership? From the district?

G. Other (non-technology) Barriers

18. Are there any other barriers to integrating Navigator into your classroom practice?

19. Are there any other initiatives that you are currently implementing at your school or throughout the district?
    Probe: To what extent do those additional initiatives compete for teachers' time?

APPENDIX D

District:

School name:

Teacher name:

TI MathForward Observation Protocol

NOTE: Please use a BLACK pen. When asked to mark boxes, make an "X" through the box. Use block printing when you complete any text or numeric responses. If you wish to change a response, mark the correct response and CIRCLE it.

OBSERVATIONAL CONTEXT

1. (a) Observer 1:

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Observer 2:

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

1. (b) This form reports the observations of: *(Mark one only.)*

☐ Observer 1 ☐ Observer 2

2. Date of Observation: *(month/day/year)*

☐☐ / ☐☐ / ☐☐☐☐

3. Length of Observation: *(hours:minutes)*

☐☐ : ☐☐

CLASSROOM SETTING

4. Number of Students Present:

☐☐

5. Grade Level: *(Mark all that apply.)*

☐ 6 ☐ 7 ☐ 8 ☐ 9

6. How are student seats arranged in the classroom? *(Mark all that apply.)*

☐ Rows
☐ 2-3 students at a small table
☐ 4-5 students at a medium table
☐ 6 or more students at a large table

1206

- -

7. Which best describes the class you are observing: *(Mark one only.)*

- ☐ Elementary math
- ☐ Middle school math
- ☐ Pre-algebra
- ☐ Algebra
- ☐ Geometry
- ☐ Integrated math
- ☐ Advanced math

8. Write down the stated objectives of today's activities.

9. Please indicate any problems, disruptions, or irregularities during the observation (e.g., fire drill, substitute teacher, partial observation).

10. Describe the level of student engagement in the classroom. Are few students engaged or most students engaged during this class period? Are students actively participating in discussions?

INSTRUCTIONAL TIME

11. Did the teacher use the TI-Navigator tool during this period?

☐ Yes

☐ No

12. If you observed the teacher using the TI-Navigator tool, which of the following tools did you observe? *(Mark all that apply.)*

☐ a. Activity Center (Interactive activities with your classes involving lists, graphs, points, and equations)

☐ b. Quick Poll (Send polls to students, receive student responses, and review poll results)

☐ c. Screen Capture (Lets teachers capture students' calculator screens)

☐ d. Learn Check and Class Analysis (Create an assessment, send to students, and analyze class results)

☐ e. App and OS Transfer (Transfer TI Graphing Calculator Operating Systems (OS) and Applications (Apps) to students' calculators)

☐ f. Transfer Tools (Multiple tools that let teachers send, collect, and delete data files on students' calculators)

13. Which of the following grouping strategies did you observe? *(Mark all that apply.)*

☐ a. Set up students in different groups

☐ b. Taught group behavior expectations

☐ c. Used learning centers and stations

☐ d. Used cooperative learning strategies

CONTENT

14. In which ways were the following concepts being taught or needed by students to complete work assigned during this period? *(Mark one for each item.)*

	Not covered	As prerequisite knowledge	As developing knowledge
a. Number Sense / Properties / Relationships	☐	☐	☐
b. Operations	☐	☐	☐
c. Measurement, Use of measuring instruments	☐	☐	☐
d. Algebraic Concepts	☐	☐	☐
e. Geometric concepts	☐	☐	☐
f. Data analysis / probability / statistics	☐	☐	☐

- -

COMPLEXITY

15. What kinds of teacher assigned tasks did you observe? *(Mark all that apply for each item.)*

	During Warm Up	During this period	For homework
a. Practice basic math facts (e.g., addition, subtraction, multiplication, and division)	☐	☐	☐
b. Read or interpret charts, tables, or graphs	☐	☐	☐
c. Make charts, tables or graphs	☐	☐	☐
d. Solve problems that have more than one correct answer	☐	☐	☐
e. Solve problems in which students practice applying a method they have been taught	☐	☐	☐
f. Solve problems in which students have to figure out what method to use to solve them	☐	☐	☐
g. Describe the procedure or algorithm they used to solve a problem	☐	☐	☐
h. Explain why a procedure or algorithm they used worked to solve a problem	☐	☐	☐
i. Prove that a particular method for solving a problem is valid	☐	☐	☐
j. Analyze similarities or differences among methods and types of problems	☐	☐	☐

ASSESSMENT

16. If students completed a TI-Navigator assessment, did you observe teachers using the following? *(Mark all that apply.)*

☐ a. Students did not complete any TI-Navigator assessments during this period.

☐ b. Diagnostic assessments (determine students' background experiences, skills, and misconceptions)

☐ c. Quick Polls (assess students' current level of understanding of concept being taught)

☐ d. Benchmarks (summative assessment of students' understanding compared with goals they were expected to achieve)

☐ e. Warm-ups (short assessments of student progress in mastering national math standards)

CLIMATE

17. To what extent did you observe the following teaching strategies? *(Mark one for each item.)*

	Not at all	Very little	Some	A major focus
a. Demonstrating a procedure step by step	☐	☐	☐	☐
b. Explaining a difficult concept using multiple representations	☐	☐	☐	☐
c. Providing time for students to practice	☐	☐	☐	☐
d. Asking students to give reasons for a given answer	☐	☐	☐	☐
e. Diagnosing students' conceptual or procedural error and re-teaching a concept or procedure	☐	☐	☐	☐
f. Probing student responses for depth and clarity	☐	☐	☐	☐
g. Taking actions to reduce students' off-task behaviors	☐	☐	☐	☐

18. What mode(s) of engagement did you observe? *(Mark all that apply.)*

☐ a. Whole class lecture

☐ b. Teacher demonstration

☐ c. Whole class discussion

☐ d. Individual student work

☐ e. Student pair work

☐ f. Student small group work

☐ g. Other. Please describe.

19. Did the teacher need to manage disruptive behavior during the period because they were off task?

☐ Yes

☐ No

If yes, how many times?

☐☐

- -

TECHNOLOGY

20. If the TI-Navigator was used, which of the following did the teacher do with the Navigator? *(Mark all that apply.)*

- ☐ a. Collect homework or other assignments
- ☐ b. Send problems or learning materials to students (e.g., apps, models, forms)
- ☐ c. Look at screen shots of a student device on the computer
- ☐ d. Display calculator screen shots for the class to view
- ☐ e. Display a distribution of student responses to a question for all to see
- ☐ f. Use the feedback from TI Navigator to make changes in instruction DURING class
- ☐ g. Resolve technical or log in problems

21. Number of students with graphing calculator:

22. Number of students having difficulty logging onto TI-Navigator:

23. What types of difficulties were students having with software or hardware?

24. Which technologies are in use during this class period? *(Mark all that apply.)*

- ☐ a. None
- ☐ b. Navigator/calculator
- ☐ c. Graphing calculator only (i.e. not networked, not used together with TI Navigator)
- ☐ d. Other technology (specify e..g. title of software programs, websites but not projector)

1206