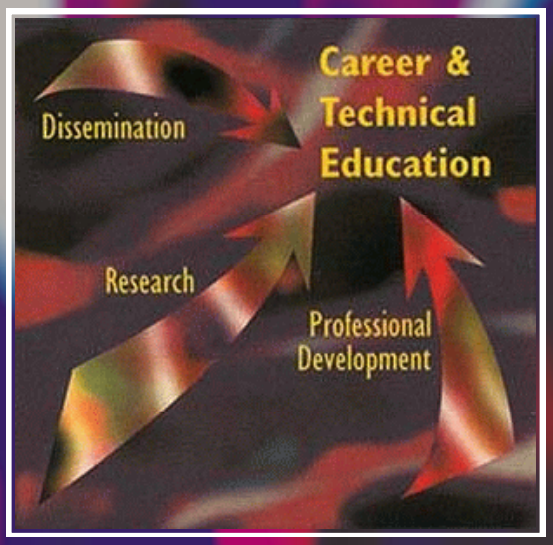

Sustaining the Impact: *A Follow-Up of the Teachers who Participated in the Math-in-CTE Study*

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EXECUTIVE SUMMARY

During the 2004-05 school year, the National Research Center for Career and Technical Education conducted a study entitled "Building Academic Skills in Context: Testing the Value of Enhanced Math Learning in Career and Technical Education," commonly referred to as the *Math-in-CTE* study. This was a random-assignment experiment that tested the effects of enhancing instruction in the mathematics inherent in the curricula for five occupational areas. Post-testing found that students of teachers who had been in the experimental group scored significantly higher than students of teachers who had been in the control group on two standardized tests of mathematics achievement: 9% higher on TerraNova and 8% higher on Accuplacer. These higher scores were the result of professional development that brought career and technical education (CTE) and mathematics teachers together to examine CTE curriculum and develop lessons that delivered explicit instruction in the math concepts inherent in the technical content. The CTE teachers taught these lessons in their regular classes, devoting an average of about 20 hours or 11% of one traditional, 180-hour, full-year class.

In this report, we present the results of a follow-up study of the teachers who participated in the experiment. We conducted the follow-up in the 2005-06 school year, the year after the experiment ended, to determine the extent to which the teachers in the experimental group had continued to use the instructional method and lessons developed for the experiment and teachers in the control group had adopted any of the lessons. We first sent a mail survey to all teachers who had been in either the experiemental or the control group, which yielded an 80% response rate. We then attempted to conduct personal interviews with all those who reported continued use or adoption and telephone interviews with those who did not. The completion rates for the interviews were lower than for the mail survey: 72% for the personal interviews and 49% for the telephone interviews.

The mail survey found that, in the school year after the experiment ended, almost three-fourths (73%) of the experimental CTE teachers continued to use the method and materials from the study, two-thirds (66%) of the experimental math teachers used examples of applications of math from the lessons, and a little over one-fourth (27%) of the control CTE teachers had taught one or more of the lessons. The personal interviews indicated that for many of the experimental CTE teachers, participation in the study had changed their approach to teaching. They had internalized the seven-element pedagogic model that had been used to develop and deliver the math-enhanced lessons to the extent that they applied it to all their teaching. Other experimental CTE teachers had not been affected to this extent, but continued to use the lessons because their participation in the study caused them to value explicit mathematics instruction that goes beyond occupational applications. Many of the mathematics teachers reported that the study had increased their awareness of the need to include practical applications of the concepts they taught and provided actual examples that they could use. Not enough time and a lack of fit with curriculum were the reasons most often given by the teachers who had not continued using the method and materials.

The control CTE teachers who taught the math-enhanced lessons after the experiment ended reported many problems in doing so. Most said they had difficulty simply understanding

the math, much less being able to teach it. These teachers had not experienced the professional development that the experimental CTE teachers had found to be essential to understanding both the math concepts and the structured, contextual approach for teaching them. The control group interviews strongly imply that simply disseminating the lesson plans developed for the *Math-in-CTE* study will not replicate its results. Essential to the procedures used in the study is extensive professional development that fosters the emergence of a community of practice focused on the improvement of instruction.

CHAPTER 1: INTRODUCTION

During the 2004-05 school year, the National Research Center for Career and Technical Education (NRCCTE) conducted a random-assignment experiment, "Building Academic Skills in Context: Testing the Value of Enhanced Math Learning in Career and Technical Education" (Stone, Alfeld, Pearson, Lewis, & Jensen, 2006). This study tested the effectiveness of enhancing mathematics instruction in occupationally specific secondary career and technical education (CTE) classes. The integration of academic and technical content to improve students' overall learning has long been advocated, but rarely successfully accomplished (Johnson, Charner, & White, 2003). Federal legislation for CTE requires that one of the core indicators used to assess effectiveness shall be "Student attainment of challenging academic content standards and student academic achievement standards, as adopted by a State . . . " (Carl D. Perkins Career and Technical Education Act of 2006, P.L. 109-270, Sec 113(b)(2)(A)(i)).

Demonstrating adequate yearly progress in academic subjects has become the primary goal of all elementary and secondary education per the No Child Left Behind Act of 2001 (NCLB) and reinforced by the latest reauthorization of federal CTE legislation. CTE must provide sound evidence to support its long-standing claim that it can contribute to this goal or it risks becoming irrelevant. This experimental study (hereafter referred to as *Math-in-CTE*) provided such evidence.

The *Math-in-CTE* study brought together CTE and mathematics instructors to identify the mathematics inherent in the CTE curricula for five occupational areas (agricultural power and mechanics, auto technology, business and marketing, health, and information technology). Once the math concepts were identified, the CTE-math teacher teams worked together to develop lessons to explicitly teach these concepts. Over the course of the school year, the CTE instructors taught the lessons for their areas, spending an average of 20 hours or 11% of the total hours for a full-year, 180-hour class on the lessons. Post-testing conducted at the end of the school year found that the students who had received these lessons scored significantly better than the control students on two tests of mathematics achievement: 9% better on TerraNova and 8% better on Accuplacer. The report of the study (Stone et al., 2006) explains the methods and results of the experiment in detail.

In the summer after the experiment ended, all control teachers were invited to take part in two-day workshops for their occupational areas. These workshops explained the research design, preliminary results, and instructional methods used in the study. Teachers from the experimental group demonstrated selected lessons and answered questions from the control teachers. About one-third (31%) of the control teachers attended these workshops. All control teachers were sent a CD with copies of the lessons that had been developed for their occupational areas. The control teachers thus had the lessons and could have begun teaching them during the school year following the experiment.

The educational literature contains many examples of innovative programs that faded away when their funding ended. The study presented in this report followed up with the teachers

from the *Math-in-CTE* study to determine if their participation had any lasting effect. Near the end of the school year following the experiment (mid-March, 2006), we contacted the teachers to determine if they continued to use or began to use materials from the experiment during the 2005-06 school year. The follow-up was designed to:

1. Determine the extent to which the experimental group CTE teachers continued to follow the *Math-in-CTE* model and the factors that influenced this continuation.
2. Determine the extent to which control group CTE teachers who received the lessons and/or debriefing-level training adopted the model and the factors that influenced this adoption.
3. Determine the extent to which mathematics teachers who worked with the CTE teachers used in their academic classes any of the occupational examples from the lessons they helped to develop, and the factors that influenced this use.
4. Determine the reasons given by teachers for not following the *Math-in-CTE* model in CTE classes or not using any occupational examples in mathematics classes.

This report presents the results of the follow-up. The remainder of this chapter reviews selected literature on sustaining educational change. Chapter 2 describes the three methods that we used to conduct the follow-up: a mail survey, personal interviews, and telephone interviews. We conducted personal interviews with CTE teachers who reported in the mail survey that they included explicit math instruction in their classes and with mathematics instructors who reported they had adopted methods or applications of mathematics from the CTE lessons for their classes. We conducted telephone interviews with the teachers who reported that they were not using anything from the study. In Chapter 3 we present the results from the mail survey and in Chapter 4 the results from the interviews, both personal and telephone. In Chapter 5, we integrate the results from the different data sources and relate these results to themes that emerged from the literature review.

Sustaining Educational Change

The literature on educational change is voluminous and often discouraging. When we entered the words "educational change" into an ERIC search, over 40,000 sources were found[1]. Limiting the search to the year 2000 or later still produced over 6,000 documents. Most of those examined in the preparation of this review describe efforts to produce change, not the results of these efforts. The few studies of the long-term effects of change efforts typically report a return to traditional practices (Cuban, 1993; Hargreaves & Goodson, 2006; Tyack & Cuban, 1995).

Efforts to sustain and expand educational innovations inevitably encounter resistance from what Tyack and Tobin (1994) refer to as the "grammar of schooling" and Elmore (1996) labels the "core of educational practice." Here is how these authors define these related concepts:

> By the "grammar" of schooling we mean the regular structures and rules that organize the work of instruction. Here we have in mind, for example, standard organizational practices in dividing time and space, classifying students and allocating them to classrooms, and splintering knowledge into 'subjects.' . . . Neither the grammar of school nor the grammar

1 The search was conducted on June 20, 2006 at the URL: www.eric.ed.gov

> of speech needs to be consciously understood to operate smoothly. Indeed much of the grammar of schooling has been so well established that it is typically taken for granted as just the way schools are. It is the *departure* from customary practice in school or speaking that attracts attention. (emphasis in the original, Tyack & Tobin, 1994, p. 454)
>
> By the "core" of educational practice, I mean how teachers understand the nature of knowledge and the student's role in learning, how these ideas about knowledge and learning are manifested in teaching and classwork. The core also includes the structural arrangements of schools, such as the physical lay-out of classrooms, student grouping practices, teachers' responsibilities for groups of students, relations among teachers in their work with students, and processes for assessing student learning and communicating it to students, teachers, parents, administrators, and other interested parties. (Elmore, 1996, pp. 294–295)

This grammar/core is a set of deeply held, largely implicit, beliefs about the teaching-learning process, what Senge (1990) refers to as "Mental models . . . that influence how we understand the world and how we take action" (p. 8). These beliefs see teachers using methods that they choose and develop (lecturing, questioning, projects, worksheets, etc.) to transmit defined bodies of knowledge (English, mathematics, auto technology, etc.) within a period of time (the class schedule) established by the school administration. Teaching is essentially an individual activity.

Many who have examined what happens in classrooms have concluded that the traditional approach to teaching/learning is not the most effective way to engage students and produce lasting change in their knowledge and skills. Elmore (1996) has summarized two of the most pervasive and persistent attempts to change the grammar/core of schooling: the progressive period in the early decades of the twentieth century and the large-scale curriculum development projects in the 1950s and 1960s funded by the National Science Foundation. He concluded, albeit with at best "circumstantial evidence" (p. 315), that at the peak of their influence these initiatives involved roughly 25% of the teachers at whom they were directed.

Elmore does not discuss the proliferation of change efforts that followed the publication of *A Nation at Risk* (National Commission on Excellence in Education, 1983), but others have (Borman et al., 2005, Carpenter et al., 2004; Fullan, 2001; Hargreaves & Goodson, 2006; Newmann & Associates, 1996). These studies have reached similar conclusions: 1) change efforts typically engage a minority of teachers; and 2) for any effort to be successful, school-level leadership and professional development that create a sense of community among teachers are essential.

As the evidence on the importance of community accumulated, interest in professional learning communities grew (Hord, 1997, 2004). Professional learning communities incorporate what is probably the most enduring finding from decades of small group and organizational research: individuals are more likely to accept change if they are involved in deciding what the change will be and how it will be implemented. Over 40 years ago, Berelson and Steiner (1964) summarized this finding as follows:

> Active discussion by a small group to determine goals, to choose methods of work, to reshape operations, or to solve other problems is more effective in changing group practice

> than is separate instruction of the individual members, external requests, or the imposition of new practices by superior authority—more effective, that is, in bringing about better motivation and support for the change and better implementation and productivity of the new practice. (p. 353)

In the years since this quotation was published, several continuous improvement models—e.g., Total Quality Management (Deming, 1986) and Six Sigma (Pande, Neuman, & Cavanagh, 2000)—emerged in manufacturing and spread to all types of organizations. All of these models incorporate methods to involve those who will be affected by decisions in the making of those decisions. Professional learning communities are one application of this principle to schools. Hord (1997) credits *The Fifth Discipline* by Senge (1990), which introduced the concept of the learning organization, with stimulating interest in learning communities among educators.

Two different sources reflect a high degree of agreement in their identification of the defining characteristics of professional learning communities:

Louis, Kruse, and Marks (1996)

- Shared norms and values
- Deprivatization of practice
- Collaboration
- Reflective dialogue
- Focus on student learning

Hord (1997, 2004)

- Shared values and vision
- Shared personal practice
- Collective learning and applications of learning
- Supportive and shared leadership
- Supportive conditions

In schools that become professional learning communities, principals are full participants committed to the vision and values of their communities and willing to involve faculty in decision-making. The primary goal of these schools is to improve student learning and teachers have time to work together to explore ways to achieve this goal. (One of these ways includes observing and critiquing each others' classes.) When all these conditions are present, teachers assume ownership for innovation, and regression to the traditional grammar/core of schooling is less likely to occur (Borman et al., 2005; Carpenter et al., 2004; Giles & Hargreaves, 2006).

Professional learning communities are explicitly created as a means to achieve defined goals. Hord (1997) and others who have studied these communities (e.g., Louis & Kruse, 1995; Sergiovanni, 1994) provide guidelines for fostering them. Jolly (2004) has used this literature to prepare a facilitator's guide complete with questionnaires, checklists, exercises, etc. designed to develop what she refers to as "professional learning teams."

The Japanese lesson study approach (Lewis, Perry, & Murata, 2006) incorporates the elements of professional learning communities on a smaller scale. A group of teachers sets goals for student learning and collaboratively designs a plan to achieve those goals. One component of the plan is a "research lesson" that one of the teachers presents to his/her students while the other teachers observe. Following the lesson, the teachers meet to discuss their observations and use this information to refine their plan, improve the research lesson, and plan additional lessons. This process organizes the five characteristics of professional learning communities presented

above into specific tasks. The process also aligns well with the principles of peer coaching as specified by Showers and Joyce (2003): "The primary activities of peer-coaching study teams are planning and developing curriculum and instruction in pursuit of shared goals" (p. 317).

As part of the *Math-in-CTE* study, we conducted observations of professional development workshops and conducted focus groups at the end of the 2004-05 school year with the experimental teachers. From these qualitative data, we found that a sense of community had developed among the teachers who participated in the study. These communities, however, did not have all the attributes discussed above. They differed primarily in that the teachers were not from a single school. They were drawn from many schools, and in most cases only two teachers per school (one CTE and one math) took part in the study. For this reason, we think the label *communities of practice* (Wenger, 1998) is more appropriate than *professional learning communities* for the entities that emerged in our study. This is also the term applied by McLaughlin and Talbert (2001) to the teacher interactions they observed in some of the schools that participated in a multi-year study of the context of secondary school teaching. As in the *Math-in-CTE* study, these communities were not purposively planned and implemented, but they did require a school culture that encouraged a shared approach to teaching.

Communities of practice are not explicitly created. Instead they emerge as people are brought together because of particular organizational arrangements or interests (Wenger, 1998). Communities of practice thus represent more of an anthropological or sociological concept that explains how groups form and interact rather than a method for developing cohesion and commitment within a group. Wenger (1998) specifically rejects thinking of them as a methodology:

> In particular, they are not a design fad, a new kind of organizational unit or a pedagogic device to be implemented. Communities of practice are about content—about learning as a living experience of negotiating meaning—not about form. In this sense, they cannot be legislated into existence or defined by decree. They can be recognized, supported, encouraged, and nurtured, but they are not reified, designable units. (pp. 228–229)

In our planning for the *Math-in-CTE* study, we did not attempt to create professional learning communities. We were not attempting to change schools. We were attempting to enhance the mathematics instruction that occurs within CTE classrooms. The importance of an emphasis on student learning is reflected in the title of a book by Joyce and Showers (2002) that summarizes their years of research on professional development: *Student Achievement through Staff Development*. The authors describe the purpose of this book as follows: ". . . we concentrate solely on staff development methods that increase knowledge *and* generate the classroom skills and practices that expand the active teaching/learning repertoire" (p. 4, emphasis in the original). This is precisely what we tried to achieve with the professional development provided to the experimental teachers in the *Math-in-CTE* study: To increase the knowledge of CTE teachers about the math concepts essential to their curriculum and to provide them with better methods for teaching those concepts.

This professional development we provided incorporated all of the features of Japanese lesson study except peer observation in actual classes. The experimental teachers examined their

curriculum to identify the mathematics inherent in their occupational areas and selected the concepts that they would explicitly teach. They designed lessons to teach those concepts and tested the lessons with their students. They met to revise and improve those lessons and practiced them with their peers.

In their article on Japanese lesson study, Lewis et al. (2006) provide two "conjectures" of why this approach may lead to instructional improvement:

1. Lesson study improves instruction through the refinement of lesson plans.
2. Lesson study strengthens three pathways to instructional improvement: Teachers' knowledge, teachers' commitment and community, and learning resources.

Lewis et al. indicate that their current thinking is that Conjecture 2 is the more compelling explanation. The authors give examples of how the three pathways may affect teachers:

Teachers' knowledge
- Knowledge of subject matter
- Knowledge of instruction
- Capacity to observe students
- Connection of daily practice to long-term goals

Teachers' commitment and community
- Motivation to improve
- Connection to colleagues who can provide help
- Sense of accountability to valued practice community

Learning resources
- Lesson plans that reveal and promote student thinking
- Tools that support collegial learning during lesson study (p. 5)

Lewis et al. label these explanations *conjectures* because they have not been systematically studied. Nevertheless, we think both conjectures apply to the results of the *Math-in-CTE* study. The CTE and math teachers working together produced better (refined) lesson plans than either would have alone, and Conjecture 2 perfectly describes many of the changes we saw in the teachers who participated in the *Math-in-CTE* study. There is no question that the CTE teachers increased their knowledge of and ability to teach the mathematics in their curricula. The teachers connected their participation in the study to the goal of improving the mathematics skills of their students. They developed learning resources that made mathematics tangible and useful to their students. As they worked together to develop and improve the lessons, a community of practice emerged within each of the five occupational areas that motivated and supported their efforts and encouraged mutual accountability.

The *Math-in-CTE* study ended, however, and with it the opportunities the study had provided to bring the teachers together. Would the teachers continue to teach the lessons when they were no longer supported by their communities of practice? This is the primary question we attempted to answer through the follow-up study presented in this report. The next chapter describes the methods we used to assemble information to answer this question.

CHAPTER 2: METHOD

The study used a mixed-method approach (Greene & Caracelli, 1997). We employed a sequential explanatory strategy (Creswell, 2003) to collect and analyze data in two phases. In the first phase, we collected quantitative data from mail surveys to ascertain the extent of continuation and adoption of the *Math-in-CTE* model. In the second phase, we conducted in-depth personal interviews and telephone interviews, and collected instructional artifacts. The qualitative data were analyzed to validate the survey responses and provide deeper description of teachers' use of the model. All teachers who participated in the full-year experiment (the experimental and control CTE teachers and the math teacher partners of the experimental CTE teachers) were included in the follow-up study.

Mail Survey

The first step in the study was to send questionnaires by mail to the three groups of teachers. (See Appendices A, B, and C for the questionnaires used.) The first mailing was done on March 17, 2006. To encourage a high response rate, all teachers were offered an incentive of $50 for returning a completed questionnaire. Teachers who were not using the model therefore had an incentive for returning the questionnaires. Honest reporting was further encouraged by the requirements to 1) complete a scope and sequence chart that listed the lessons taught or to be taught using the model, and 2) commit to participating in a follow-up interview about these lessons.

Those who had not responded within four weeks were contacted by telephone and asked if they had received the questionnaire. Almost all said they had but had put it aside to complete later. Only one said he had but did not want to participate. Those who said they had not received questionnaires were sent them. A second mailing was made to those who could not be reached by telephone or had not responded by seven weeks after the first mailing. Table 1 shows the number of mail questionnaires sent and the number returned by the cutoff date: June 23, 2006.

Table 1. *Questionnaires Mailed and Returned*

Teacher Group	Mailed	Returned	Response %
Experimental	60	46	76.7
Control	73	60	82.2
Mathematics	52	43	82.7
Total	185	149	80.5

Interviews

CTE teachers who reported including explicit math instruction in their lessons were contacted and asked to participate in personal interviews that were structured to ascertain the extent to which the *Math-in-CTE* model had been sustained. An incentive payment of an additional $50 was offered for participation in the personal interviews. Teachers who reported in the mail ques-

tionnaire that they did not teach explicit math were contacted by telephone to verify this and, if possible, to discuss the reasons they had reported for not using the lessons from the study. No incentive was offered for the telephone interviews. Table 2 shows the number of personal and telephone interviews that were completed.

Table 2. *Follow-up Personal and Telephone Interviews Completed with Teachers who Returned Completed Mail Questionnaires*

	Questionnaires returned	Interviews conducted	% Interviews conducted
Personal interviews			
CTE Experimental	33	29	87.5
CTE Control	20	12	60.0
Mathematics	19	11	57.9
Total	72	52	72.2
Telephone Interviews			
CTE Experimental	13	7	53.8
CTE Control	40	18	45.0
Mathematics	24	13	54.2
Total	77	38	49.4

The interview completion rates for all groups except the CTE experimental teachers who taught explicit math were lower than the mail survey response rates for all groups. This was surprising because all of those contacted for interviews had already returned completed mail questionnaires, and the requests for participation in interviews came from site staff who had worked with the teachers during the experiment. Part of the explanation for the low rates is that many of the requests were made after the school year ended. We had waited until close to the end of the school year (mid-March 2006) to conduct the first mailing of the survey. The follow-ups to the original mailing extended to the end of the school year. After the school year ended, the interviewers had difficulty contacting the teachers. Attempts to contact teachers ceased when there was no response to repeated e-mail and voice mail messages.

The personal interviews typically lasted 40-60 minutes. They focused on two lessons randomly selected from the scope and sequence charts. (See Appendix D for an explanation of how the lessons were selected.) The pedagogic framework developed for the original *Math-in-CTE* study was used to structure the personal interviews with experimental teachers who continued to use the lessons and control teachers who began to use the lessons. Typically referred to as the "seven elements," teachers used the following framework to develop, present, and refine their math-enhanced lessons:

1. Introduce the CTE lesson.
   - Explain the CTE lesson.
   - Identify, discuss, point out, or pull out the math embedded in the CTE lesson.
2. Assess students' math awareness as it relates to the CTE lesson.
   - As you assess, introduce math vocabulary through the math example embedded in CTE.
   - Employ a variety of methods and techniques for assessing awareness of all students—e.g., questioning, worksheets, group learning activities, etc.
3. Work through the math example *embedded* in the CTE lesson.
   - Work through the steps/processes of the embedded math example.
   - Bridge the CTE and math language. The transition from CTE to math vocabulary should be gradual throughout the lesson, being sure never to abandon completely either set of vocabulary once it is introduced.
4. Work through *related, contextual* math-in-CTE examples. Using the same math concept *embedded* in the CTE lesson:
   - Work through similar problems/examples in the same occupational context.
   - Use examples with varying levels of difficulty; order examples from basic to advanced.
   - Continue to bridge CTE and math vocabulary.
   - Check for understanding.
5. Work through *traditional math* examples. Using the same math concept as in the *embedded* and *related, contextual* examples:
   - Work through traditional math examples as they may appear on tests.
   - Move from basic to advanced examples.
   - Continue to bridge CTE and math vocabulary.
   - Check for understanding.
6. Students demonstrate their understanding.
   - Provide students opportunities for demonstrating their understanding of the math concepts embedded in the CTE lesson.
   - Tie the math examples back to the CTE content; conclude the lesson on the topic of CTE.
7. Formal assessment.
   - Incorporate math questions into formal assessments at the end of the CTE unit/course.

The teachers were asked about each of the seven teaching elements around which the math-enhanced lessons had been developed. They were asked if they covered each element and if so, the steps and problems covered in the element. Interviewers also requested copies of any instructional materials/artifacts the teachers used to support their math-enhanced lessons, such as handouts, PowerPoint slides, learning games, quizzes, etc.

In addition to the focus on the randomly selected lessons, the interviewers elicited the teachers' descriptions of sustaining the *Math-in-CTE* model in their classrooms without the benefit

of the structure provided by the research study. The interviewers obtained information on the extent to which CTE and math teachers maintained their communities of practice and their partnership with each other. Other issues were also examined, such as the barriers to sustaining the model following the study and adjustments or changes needed. The interviews were taped and transcribed for analysis. (See Appendix E for the questions used in the personal interviews with CTE teachers.)

The ways in which participation in the study might influence traditional math classes could be quite varied, so the personal interviews conducted with the math teachers who reported that their classes were affected were less structured than those with the CTE teachers. The interviews began with general questions about how the math teachers contributed to the *Math-in-CTE* research and the lessons they helped to develop. The teachers were also asked about the aspects of the professional development that they found most and least helpful and if they had maintained contact with the CTE instructors with whom they were paired in the study.

The interviews then moved to the courses the math teachers had taught or were teaching and any instances in which they used problems, concepts, or applications of mathematics derived from the *Math-in-CTE* lessons. As with the CTE instructors, the interviewers requested copies of instructional artifacts that documented the use of *Math-in-CTE* materials or approaches. The math teachers were also asked to describe their overall experience of transferring innovations learned by participating in the research into their traditional practice, including those influences in their teaching environment that facilitated or hampered their attempts. These interviews were also recorded and transcribed. (See Appendix F for the interview questions used with mathematics teachers.)

Telephone interviews were conducted with the teachers who reported that they had not used any of the *Math-in-CTE* materials or approaches since the end of the study. These interviews were brief (only lasting five to ten minutes) and attempted to encourage some elaboration concerning the reasons experimental teachers had chosen to discontinue use of the lessons and control teachers had not tried to teach any of them. Interviewers were trained to maintain openness to answers that were not supportive of the research or the model.

The mailed questionnaires included a short list of reasons for not using anything from the study; the teachers checked any that applied to them. In the interviews, the interviewers cited the reasons the CTE teachers gave for not explicitly teaching math and the math teachers gave for not using any of the occupational applications. The interviewers encouraged the teachers to elaborate and give the background for the reasons they had checked and probed further on any unclear responses. The telephone interviews were also recorded and transcribed. (See Appendix G for the questions used in the telephone interviews.)

As noted, all the interviews, personal and telephone, were recorded. These recordings were transcribed verbatim. The authors began the qualitative data analysis by conducting independent analyses of the interview transcripts. One author read and coded the transcripts using NVivo 7 software. The other read all the transcripts and developed broad themes for grouping the coded segments. Once the independent analyses were complete, the two authors reached consen-

sus on the themes to be developed and presented in order to extend the credibility of and elaborate on the quantitative survey findings (Creswell, 2003).

No formal analysis of the instructional artifacts was conducted. Artifacts submitted by the teachers were highly variable. About half of the teachers had not kept any after they had taught the lessons. The primary reason for asking the teachers to provide artifacts was to confirm that the lessons had actually been taught. Because many teachers could not provide them, this objective was only partially fulfilled. There were no indications from the interviews, however, that those teachers who did not provide artifacts differed in any way from those who did. Project staff who had worked with the teachers during the study conducted the interviews. Debriefing with these individuals following the interviews yielded no suggestion of false reporting.

The results produced by this mixed-method approach to data collection and analysis are presented in the next two chapters. The quantitative findings from the mail survey are the focus of Chapter 3. Chapter 4 presents analysis of the personal and telephone interviews thematically. In the final chapter, we discuss these findings and their implications for sustaining educational change.

CHAPTER 3: THE MAIL SURVEY

This chapter reports the results from the first phase of the study: the mail survey of all the teachers who participated in the *Math-in-CTE* study. The results for the CTE teachers are presented separately from the results for the mathematics teachers. The results for the CTE teachers include those from both the experimental and control groups. The control teachers were included in the follow-up because they had been sent CDs with the lessons for their occupational areas and thus could have adopted these lessons for their classes. The extent to which they did so provided information on the "user friendliness" of the lessons. To what degree would teachers adopt these lessons with little or no professional development on their use? We could distinguish between those with little and those with no professional development, because only about one in four (27%) of the control teachers who returned questionnaires had attended the workshops held after the 2004-05 school year. Separate workshops were conducted for each of the occupational areas to acquaint the control teachers with the seven-element pedagogic model discussed in Chapter 2 and to demonstrate sample lessons.

The second section of the chapter presents the results from the mathematics teachers. These teachers were surveyed because focus groups conducted after the study ended had indicated that several of them intended to use examples of applications of mathematics from the lessons they had helped to develop in their classes. We wanted to determine how many of the mathematics teachers had used such examples, and if they had not, why not.

Career and Technical Education Teachers

The questionnaires sent to the CTE teachers included two screening questions. First, were they teaching CTE courses that prepared students for employment during the 2005-06 school year? Those who replied "Yes" were asked if they included *explicit mathematics instruction*, defined as "going beyond specific occupational applications to explain the general math concepts that underlie the applications." If they answered "Yes" to this question, they were asked about the approach they used to teach mathematics and if they had taught or planned to teach any lessons from the study. Those who were teaching CTE courses but not including explicit math were asked their reasons for not doing so. The results from both groups follow.

Teaching Explicit Mathematics

Three-fourths of the experimental teachers who responded said that they were teaching explicit math, almost double the percentage of control teachers who were (see Table 3). Virtually all of these experimental teachers were using the seven-element model that had been tested in the study. Because the base numbers of the percentages in Table 3 are fairly low, we report the actual numbers as well as percentages where appropriate. Stated in terms of actual numbers, of the 33 experimental teachers who reported teaching explicit math, 30 were using the seven elements, 2 were not using the approach but were using some of the lessons from the study, and 1 was using state-developed/approved materials. Among the 20 control teachers who included explicit math

instruction in their courses, 7 reported that they had adopted the *Math-in-CTE* approach and an additional 7 were using lessons from the study but were not following the seven elements model.

Table 3. *Use of* Math-in-CTE *Method or Materials During 2005-06 School Year by Experimental and Control CTE Teachers, Respondents and Estimates for Total Sample*

	Respondent %		Total Sample %	
Use of Method or Lessons	All	Those Teaching	All	Those Teaching
Experimental Teachers				
Taught explicit math	71.7	75.0	55.0	56.9
Used *Math-in-CTE* method and lessons	65.2	68.2	50.0	51.7
Used lessons not method	4.3	4.5	3.3	3.4
Used other methods	2.2	2.3	1.7	1.7
Did not teach CTE courses	4.3		3.3	
Did not teach explicit math	23.9	25.0	41.7	43.1
Base for percentages	46	44	60	58
Control Teachers				
Taught explicit math	33.3	38.5	27.4	30.8
Used *Math-in-CTE* method and lessons	11.7	13.5	9.6	10.8
Used lessons not method	11.7	13.5	9.6	10.8
Used other methods	10.0	11.5	8.2	9.2
Did not teach CTE courses	13.3		11.0	
Did not teach explicit math	53.3	61.5	43.8	69.2
Base for percentages	60	52	73	65

Note. The percentages for Total Sample are estimates that were calculated assuming that teachers who did not respond did teach and did not use the method or lessons.

There is no indication that the control teachers who attended the professional development workshops conducted after the 2004-05 school year were more likely to use the study lessons. Among the 20 controls who taught explicit math, 7 (35%) had attended the workshop and all of them were using the lessons. Among the 32 who were teaching CTE courses but not teaching explicit math—i.e., not using the lessons—9 (28%) had attended the workshop. This difference is not significant ($x^2 = .27$)

Approaches other than the *Math-in-CTE* model that the control teachers used included district/school specific materials (4), Math Across the Curriculum (4), CORD materials (2), state developed/approved materials (1), and the following other methods (responses taken directly from the mail questionnaires):

- Medical math textbook and exercises pertaining to lesson
- Not all students that take my class have the same math background/math pretesting/reinforcement of math concepts/extra study/practice applications applied math

- Combination of approaches developed by myself that included academic teacher suggestions from various schools and using student feedback and TQM feedback from XandR tools I created
- Auto lab computer system
- I use basic principles that are incorporated into state curriculum
- On the job situations for math use and needs, Cost of materials, cost of consumables, cost of labor, ratios, weights, etc.

The total number of approaches exceeds the 20 control teachers who taught explicit math, because 4 of the respondents indicated that they were using two methods.

In addition to the results from the mail surveys, Table 3 provides estimates of the use of the *Math-in-CTE* method or materials for all who were surveyed, including those who did not respond to the survey—i.e., all who had participated in the experiment. These estimates were made assuming those who did not respond were teaching courses in which the model or materials would be appropriate but not using anything from the study. Even with these conservative assumptions, half of the experimental (52%) and almost one-fourth (22%) of the control teachers were using something from the study.

At the time of the first mailing, mid-March 2006, 29 of the experimental teachers had taught an average of 4.97 of the lessons developed for the study, and 21 planned to teach an average of 3.62 additional lessons in the remainder of the school year. (Information obtained in the follow-up interviews indicated that these were more hopes than actual plans. The interviews conducted close to the end of the school year or in the summer found that few of these "planned" lessons had actually been taught.) Among the control teachers, 15 replied that they had taught or planned to teach lessons from the study, but most used only one or two of the lessons. One control teacher, however, reported using "ten plus."

The teachers tended to use the lessons as they had been written. Those who used the lessons were asked to rate how many they had modified on the five-point scale shown in Table 4. Those who had made any changes were asked to describe why they did so. Although the teachers modified relatively few lessons, 21 from the experimental group and 10 of the control group described changes they had made. The most frequent change, reported eight times, was to make the lessons a better fit, e.g. "Fit my curriculum, better fit my style of teaching." Adding clarification and explanation was reported seven times, e.g. "To make it easier to understand." Shortening the lessons was reported six times, e.g., "I cut out some of the assignments due to time issues." Modifying lessons to fit the needs of students was indicated five times, e.g. "So students of different skill levels could benefit." The remaining five reported changes could not be grouped. They referred to use of PowerPoint slides, teaching of decimals, use of one's own evaluation materials, looking for better structure, and altering the scope and sequence for teaching.

Table 4. *Ratings of Number of Lessons Changed by Experimental and Control CTE Teachers*

Ratings of Lessons Changed	Experimental %	Control %
I did not modify or change any of the lessons	31.3	33.3
I modified or changed a few of the lessons	31.3	53.3
I modified or changed about half of the lessons	3.1	6.7
I modified or changed most of the lessons	21.9	6.7
I modified or changed every lesson	12.5	
Base for percentages	32	15

In addition to the question on lessons taught, the teachers were asked if they had used or planned to use *parts* of the lessons. "Parts" was italicized in the questionnaire and followed by "(*but not the whole lesson*)." Despite this attempt to distinguish teaching parts from teaching the full lesson, four of the respondents appeared to be confused. They reported identical, or almost identical, numbers of partial and whole lessons taught and planned. The sum of these exceeded the number of lessons that had been developed for their occupational areas. If these four are excluded, 13 of the experimental and 11 of the control teachers had taught, on average, parts of two additional lessons and planned to teach parts of two more.

The questionnaire listed four possible reasons for explicitly teaching math; the teachers were asked to check all that applied to them. Their responses are presented in Table 5. On average the teachers checked more than two of the reasons. The other responses included:

- To help with [state standardized test] proficiency.
- Students need remedial instruction.
- It is an integral part of my curriculum.
- It also aids in their understanding of the technology involved in the math lesson, i.e. Pascal's Law-hydraulics principles.
- Students need to know math is embedded in all aspects of life and classroom.

Table 5. *Reasons Given by CTE Teachers for Including Explicit Mathematics Instruction in Their Classes in the School Year after the Experiment Ended*

Reasons	Experimental %	Control %
I recognize the value of the approach	84.8	65.0
Improves my courses, better prepares students for jobs	75.8	80.0
I have the knowledge/confidence to teach math	51.5	35.0
School/district requires math in all courses	9.1	30.0
Other	18.2	20.0
Total	239.4	230.0
Base for percentages	33	20

Note. Total exceeds 100% to the extent that teachers gave more than one reason.

Among those who reported explicit math instruction, two-thirds (22) of the experimental teachers continued to contact the math instructor with whom they had been paired during the study in order to review math concepts. An additional 12% (4) had contact with a different math instructor. The frequency of contact was almost equally distributed across the five categories that ranged from less than once a month to almost every day. Among the controls who taught explicit math, just over half (11) received some support from a math teacher. For most of these 11, however, contact with math teachers was not frequent: 6 met less than once a month, 1 met once a month, 2 every two or three weeks, and 2 once a week.

Not Teaching Explicit Mathematics

Thirteen of the experimental and 40 of the control teachers who responded to the survey were not teaching explicit math. From the experimental group, one had retired and one was not teaching CTE courses. Of the 40 in the control group, three did not teach in the 2005-06 school year and five did not teach CTE courses that prepare students for employment. This left 11 from the experimental group and 32 controls teaching occupationally-specific courses but not including explicit math instruction. Table 6 presents the reasons they gave for not teaching math. (Because there are only 11 experimental teachers, both the numbers and percentages are reported.) The main reason, given by over half of each group, was lack of time/too much occupational content to cover. The percentage of control teachers citing lack of background/experience in math was not much higher than among the experimental teachers.

Table 6. *Reasons Given by CTE Teachers for Not Including Explicit Mathematics Instruction in Their Classes in the School Year After the Experiment Ended*

	Experimental		Control	
Reasons	*n*	%	*n*	%
Do not have time, too much occupational content to cover	6	54.5	18	56.3
Do not have background/experience to teach math	1	9.1	5	15.6
Do not have access to math teacher to provide support	1	9.1	5	15.6
Do not think it appropriate to teach math in my classes			1	3.1
Other	4	36.4	12	37.5
Total	12	109.1	41	128.1
Base for percentages		11		32

Note. Total exceeds 100% to the extent that teachers gave more than one reason.

The reasons listed in Table 6 were presented in the survey questionnaire; the teachers were asked to check all that applied. The total indicates that one experimental teacher and nine control teachers checked more than one reason. Over one-third of each group, a fairly high response to an open-ended prompt, wrote in other reasons or explanations for why they did not teach math. See Appendix H for the complete list of these reasons as taken directly from the questionnaires.

Health teachers were over-represented among the 11 from the experimental group who taught in 2005-06 but reported in the mail questionnaire that they did not continue use of the study methods or materials. Of the 60 experimental teachers, 21 (35%) were from health. Among the 11 not using the lessons, 7 (64%) were from health. As noted above, the reason some of these 7 gave is that the lessons had been designed for the health core, which is taught in the first year of the program, and in the 2005-06 school year, they were teaching second-year students.

Mathematics Teachers

Focus groups conducted with the mathematics teachers at the end of the *Math-in-CTE* experiment found that many of them had used or were planning to use examples from the lessons that had been developed for the study in their classes. This finding led to the decision to include these teachers in the follow-up. Screening questions similar to those asked of the CTE teachers asked if they were teaching math and if they had included any of the methods or examples of applications of math from the lessons developed for the study in their math classes. Those who used either were asked to describe what they had used. Table 7 presents the results and estimates for the total sample.

Table 7. *Use of* Math-in-CTE *Method or Materials during 2005-06 School Year by Mathematics Teachers, Respondents and Estimates for Total Sample*

	Respondents %		Total Sample %	
Use of Method or Materials	All	Those Teaching	All	Those Teaching
Used *Math-in-CTE* method or examples	44.2	65.5	36.5	50.0
Used both method and examples	14.0	20.7	11.5	15.8
Used teaching method not examples	7.0	10.3	5.8	7.9
Used examples not method	23.3	34.5	19.2	26.3
Did not teach high school mathematics	32.6		26.9	
Did not use examples or approach	23.3	34.5	36.5	50.0
Base for percentages	43	29	52	38

Note. The percentages for total sample are estimates that were calculated assuming that teachers who did not respond did teach math and did not use anything from the study.

A little over half of those teaching math (16) listed ways in which they used examples from lessons they had helped to develop. They were distributed across the occupational areas. The teachers who had worked with auto technology teachers had adopted applications of Ohm's, Pascal's, and Watt's laws, and the geometry involved to calculate cylinder displacement. Those who worked with business/marketing teachers incorporated the equations required to calculate break-even points for sales and costs, and the calculation of simple and compound interest. The partners of health teachers used the application of geometry to calculate the surface area of the body. The partners of agricultural teachers cited graphing problems and the geometry required for construction projects. None of the math partners of the information technology teachers reported that they used examples from the lessons they had helped to develop.

The seven-element teaching approach was defined in the questionnaire sent to mathematics teachers as "going from specific occupational applications to general math underlying the applications." The teachers were asked if they had adopted any parts of this approach and nine reported that they had. All of them said that they had used contextual examples, and some of them added that they have always taught that way, e.g. "That is actually the way I always taught math—a real problem first—and then the skills necessary to solve it."

A little over one-third of the teachers who taught high school mathematics in the 2005-06 school year (10) reported that they had not used the method or any examples. These teachers were given a list of possible reasons for not using anything from the study and asked to check all that applied. Their responses are presented in Table 8. Because the base for the percentages is only ten, both the actual numbers and percentages are shown in the table.

Table 8. *Reasons Given by Mathematics Teachers for Not Using Method or Examples in the School Year After the Experiment Ended*

Reason	*n*	%
Examples from CTE lessons do not fit in my curriculum	7	70.0
Curriculum too full already, cannot bring more material in	5	50.0
Math in these lessons is not at a level appropriate for my classes	2	20.0
Occupational examples too specific, students lack background	1	10.0
Other	1	10.0
Total	16	160.0
Base for percentages		10

The main reason given by seven of the ten for not using examples from the study lessons in their classes was lack of fit. Almost as many (five) also said their curriculum was too full. Only two indicated that the level of the math was not appropriate for their classes. The single "other" answer was that the CTE teacher in the building was already teaching many of the lessons and there would be too much overlap.

The math teachers were asked if they had had contact during the school year with their CTE partners from the study to review the teaching of math concepts; 55% said they had. This was lower than the 66% obtained from the parallel question asked of the CTE teachers. Since only about 80% of each sample had responded to the survey, the discrepancy might have been due to lack of matches in respondent pairs. To test this explanation, the responses of 25 CTE-math partners, both of whom had responded to the survey, were compared. The answers of 16 of these 25 (64%) agreed; 11 both said they had had contact with one another and 5 both said they had not. Eight (32%) of the CTE instructors reported contact that their math partners did not confirm. Only one (4%) of the math instructors reported a contact that his/her CTE partner did not confirm. There is no apparent explanation for why several CTE teachers reported contact which their math partners did not confirm. The math teachers were almost as likely to report contact with other CTE instructors as with their partners from the study; 13 of the math teachers (45%) reported such contact.

The math teachers who reported contact either with their study partners or other CTE instructors to review the teaching of math concepts were asked to rate the frequency of this contact on a five-point scale. Table 9 presents the definitions of the ratings and the frequency with which the teachers selected each. The distributions are fairly similar with the two lower frequencies being chosen a little more often in both.

Table 9. *Ratings by Mathematics Teachers of Frequency of Contact with CTE Partners from Study and Other CTE Instructors to Review Teaching of Math Concepts During 2005-06 School Year*

	CTE Partners from Study		Other CTE Instructors	
Frequency of Contact	*n*	%	*n*	%
Less than once a month	5	29.4	3	23.1
Once a month	4	23.5	4	30.8
Once every two or three weeks	1	5.9	2	15.4
About once a week	3	17.6	2	15.4
Almost every day	4	23.5	2	15.4
Base for percentages		17		13

Summary

Almost three-fourths (73%) of the experimental teachers who taught occupational courses during the school year following the *Math-in-CTE* study continued to teach explicit math in their classes using lessons from the study. Two-thirds of the mathematics teachers who had worked with the CTE teachers to develop the lessons and who taught math in the year following the study used the seven-element teaching approach or examples of applications of mathematics from the lessons in their classes. Slightly over one-fourth (27%) of the control teachers who taught occupational classes adopted lessons from the study. The main reason given by both experimental and control CTE teachers who were not teaching explicit math was lack of time/too much occupational content to cover. The main reasons given by mathematics teachers for not using examples from the lessons were lack of fit with their curriculum and lack of time. The communities of practice did not continue after the experiment ended. Most of the CTE and math teachers who had created the lessons had limited contact (once a month or less) after the experiment ended. In the following chapter, we discuss the findings of the follow-up interviews that were conducted with those who participated in the mail survey. These interviews collected information that was used to validate and expand upon the results of the mail survey.

CHAPTER 4: INTERVIEWS WITH TEACHERS

This chapter presents a qualitative, thematic analysis of the interviews conducted with the teachers in the second phase of the study. The purpose of these interviews was to establish the credibility of and lend more detail to the results of the mail survey. We conducted personal, face-to-face interviews with CTE teachers who reported teaching explicit math and with math teachers who reported using materials and methods from the study in order to verify and expand upon their responses to the mail survey. Also interviewed were control teachers who had taught lessons developed for the *Math-in-CTE* study or who were using other methods to teach math concepts.

We also conducted telephone interviews with the experimental and control CTE teachers who did not teach explicit math in the school year following the study and with the math teachers who did not use anything from the study. While participation in the experimental group had a strong effect on most, some experimental CTE and math teachers did not continue to use its methods or materials. A majority of the control CTE teachers did not attempt to use the lessons. The reasons they gave for not continuing or adopting the lessons are discussed in the second section of this chapter.

Teachers Using the Model

In our interviews with them, the teachers reflected on their participation in the original *Math-in-CTE* study as they discussed their continued use of the model. The experience was expressed in terms as simple as, "It has made me a better teacher," as well as in more complex descriptions of how the model became an "internalized way of thinking about teaching." One CTE teacher explained that following the model just "became a habit." Another long-time teacher expressed it this way:

> I am an old pro, I've got 33 years, and [the *Math-in-CTE* model] has changed what I do. . . . I've enjoyed it immensely. It has given me new life, the lessons we developed. I even kept the original ones. I was able to help some of the other teachers with them this year.

In the interviews, the teachers spoke of the importance of the process behind the pedagogy and how the professional development they were provided was an essential part of their ability to use the lessons they developed. The professional development had both evoked ownership of the lessons and bolstered the confidence of the teachers to teach the math. As this teacher explained, it was a process that he could not have provided for himself:

> I didn't have the tools. I didn't have the knowledge. I didn't have the discipline and I didn't have the confidence and I did not have the sincerity. . . . You need to go through the process of helping to build the lesson and put your own spin on it and you feel you can teach that to just about anybody.

The math teachers also internalized the model, but in a more generalized sense, as reflected in this comment:

> I think that this has been one of the best experiences for me to develop my teaching ability, just because of the fact that it really gets you looking at how to connect your math into what the kids are interested in. . . . When they ask the question, "How am I ever going to use in this in life?" by having all these things consciously in your head, you can say, "Well, here's how you can use it in life."

While the overarching theme, the "internalizing" of the model by the teachers, pointed to the transformative nature of the *Math-in-CTE* experience, there were differences among the teacher groups in how this experience was expressed.

Experimental Group CTE Teachers

The experimental group CTE teachers described the "internalizing" of the model in terms of how they embraced the actual pedagogic framework, the seven elements. As one teacher noted, "If you follow the model and the basic seven steps, it works, the whole thing, but you need all seven, you can't skip. . . . You may not do them all in one day . . . but you can't skip." Furthermore, the teachers indicated that they remained intentional about moving through the seven elements in order to explicitly teach the math:

> I think in all my lessons . . . I was able to bring out mathematical concepts. Prior to doing the step-by-step process when I was in business class I really only spoke in terms of business and after doing the study, now when I do something that, you know, uses a math term like 'ratios,' or 'weighted average,' I utilize that when I am lecturing to the students.

Many of the CTE teachers we interviewed were still working on their math knowledge and asking for math help but reported having more confidence than they had prior to their participation in the study. They continued to seek ways to teach the math during their instruction whether they had lessons developed or not. "This study awakened me, if you will, to the embedded math in all of the classes [I teach]. In doing so, I've tried to bring that out more than I did previously." Another teacher explained it this way:

> I'm very comfortable with the model, the model seems very sound and I really believe in it so I've actually embraced the model. Now what I find is that what I'm trying to do is find how to implement the model in other general education areas such as language arts.

While the teachers reported carefully following their lesson plans, it was clear that they had become practiced and confident with the model and sought to broaden its use, not just through the lessons they developed, but by expanding into other classes and other academic areas.

Math Teachers

The math teachers also reported internalizing the *Math-in-CTE* model, but in a way that was different from the CTE teachers. In the follow-up interviews, math teachers described how their participation in the study and use of the model had affected how they thought about teaching math as well as their teaching practice in more general terms. As one teacher disclosed,

> . . . having done it for so many years, [I] kind of maybe lost sight of the fact that I needed also to tie that in with general math problems or other math in the real world that uses those concepts. . . . I'm sure I did it to a certain extent but I wasn't very conscious of it. Now I'm thinking more of that as I go along.

This teacher added, "It inspired me, I mean, it invigorated me and for me thinking again and getting new ideas, fresh ideas and that just helps with your teaching . . . "

In the original *Math-in-CTE* study, we identified the complementary nature of the CTE and math teacher approaches to teaching the math: while the CTE teachers learned to extend students' math learning from the embedded contextual applications to traditional math examples, the math teachers gained contextualized examples with which to supplement their procedural instruction of math. The development of this "bridging" process promoted a mutual respect among the teachers in a way that not only fostered the communities of practice, as illustrated in the quote just above, but subsequently led to a broader sharing of the model by the math teachers in the year following the study. As this math teacher shared:

> I think I am more able to work with other teachers. I've had some other teachers come to me and say, "Hey, I've got this idea for a project in my class. Can you help me with it?" And I think I've been more interested in helping them with it and not seeing it so much as an intrusion.

Unlike the CTE teachers, the majority of the math teachers who reported using the model did not frame its use in terms of following the lesson plans or the seven elements. Instead, they described it more as a mental model, as illustrated in this teacher's comment: "I would say it's probably now just more something that I kind of keep in my head as I'm planning a lesson . . . to follow the same process. . . . I try to keep them [the seven elements] in the back of my mind."

However, the math teachers also reported adapting or using parts of lessons to help their students grasp the math concepts better*:*

> How can I make this useful for kids and how can I change it so that it's more concrete . . . I guess it challenges us to think about the way we teach every day and that maybe how we're doing it isn't perfect.

As the math teachers used or referenced the lessons, they were more inclined to extract contextualized examples to lead them into the more procedural math learning, as this teacher described:

> I believe that the model is a better way to teach math because it starts the kids off by giving them a contextual example so that they can see what the point is in learning the math that we are teaching them. . . . They actually see the context on either end of the spectrum, where most math curriculum usually will either teach all the procedures and then have kids do word problems or else it's the opposite where they teach the concept and hope the kids are going to just develop so that magically they can go and do these. . . . It just wraps it all up so they get both pieces of it.

Perhaps the most compelling evidence of changed practice was found in comments like this one, which shows how math teachers perceived their students differently:

> It was a real eye-opener. . . . I've spent more time trying to . . . teach on the students' level and I think I realized that when we had to bring the math that was embedded in those lessons down so the [CTE] teachers could understand it, all of a sudden . . . you start seeing where kids are. If an adult doesn't understand it, as a teacher, you know your students are having trouble.

Control Group CTE Teachers

As reported in the previous chapter, significantly fewer control teachers reported using the *Math-in-CTE* lessons than experimental group CTE and math teachers. Additionally, analysis of the interview data showed no evidence that control teachers internalized the model as the experimental teachers had. Sometimes a theme is supported by a conspicuous absence of data. This was the case with control teachers whose interviews were essentially void of description about changed teaching practice—a void which provides a contrast that further illuminates the experience of the experimental group teachers.

This difference may be understood as a function of the *Math-in-CTE* study, in which the control group teachers were required to conduct "business as usual" in their classes. At the end of the study, we provided control teachers with two days of training in the model, which was voluntary (31% participated). All control teachers were mailed CDs of the lessons and instructional materials for their occupational areas. However, they did not map their curriculum, develop lessons, or learn and practice the math embedded in their curriculum. Additionally, they did not receive ongoing support from a math teacher partner or participate in a community of practice.

The interviews with the control teachers revealed that they were excited about the opportunity to adapt a proven and successful model, but found it daunting. Their experience was not one of internalizing the process, but of struggling to understand the model without the benefit of the extended professional development their experimental counterparts received. One teacher described how the training session contributed to her insecurity:

> For someone like me, even looking at the piece of paper and looking at the steps, I still wasn't conceptualizing some of the information—the graphs, especially some of these more complicated graphs and more complicated equations. I just don't know what I am going to do. I know I have to do it, but I am worried. I wished it [the summer two-day workshop] had been longer and I wished they had done it step-by-step with us until we felt comfortable and then moved on to the next one.

Other teachers indicated that if a lesson was not well developed, they usually did not attempt to teach it. Because their training was limited, the control teachers using the lessons relied heavily on the lesson plans and accompanying curriculum materials. As this teacher explained,

> I actually use, if not the entire lesson, at least bits and pieces of all of it from the estimating to the Ohm's law to all of the rest. . . . It actually saves me a lot of hassle because it's already done and it's done where I can understand it and bring it down to the kids.

There was little evidence to show that the control teachers were integrating the lessons into their curriculum in a systematic or holistic way, or that they fully conceptualized the transfer-of-learning theory embedded in the seven elements framework. Instead, most interviews suggested that control teachers viewed the lessons as "good curriculum" and were inclined to pick and choose among the lessons and parts of lessons, as this teacher suggested: " . . . [W]hen I have good curriculum available to me like this, that's planned, I can sit down and review that and evaluate it and see that it fits what I'm doing and then utilize it." As another explained, "I think I wanted to fit not just an hour-and-a-half segment so that last portions of it I took off."

The interviews indicated that the control teachers, while enthusiastic about the opportunity to employ a proven model, struggled to teach the lessons without help. They frequently defaulted to using parts of lessons as teaching strategies or blending them into other approaches with which they were engaged.

Why Teachers Used the Model

When we asked teachers to tell us why they continued to use the *Math-in-CTE* model, they provided a variety of reasons, including the importance of preparing students for the workplace. "It's what the workplace demands," one control group teacher explained. She continued:

> The math is a necessary tool even if you or your students are not comfortable with it. Our second year program is for pharmacologists and uses ratios and proportions and things like this. And you could kill somebody if you do not know what you are doing. This is one of the reasons that I thought this could be exciting to try.

A number of teachers also spoke of the need to convey to administrators and policymakers the importance of CTE's role in contributing to the academic improvement required by No Child Left Behind and students' overall academic achievement. As one agricultural teacher explained:

> I think it's very, very important . . . that students and those who critique our programs understand that math is very important in agriculture, whether it's calculating spray rate to set up to spray a pasture or crop or anywhere else those calculations would have to be made—to be a good producer or applicator, or to utilize the best management practices . . .

"It Works!"

While reasons like those given above are compelling, the overarching reason for teachers using the model was summed up in two words: "It works!" Underlying this confidence in the model was the unspoken understanding that they had been a part of a research study with significant results. This understanding was affirmed by their experience of seeing its direct benefit to the students in their own classrooms. As one automotive teacher shared:

> I can't put it any other way, but it really, really does work. And again, the biggest impact it had on me was the fact that . . . [the students] not only learned the math and were now confident with it, but what it really helped me do was teach them the theory of the trade. . . . They get the technology, they get the math, they get it all.

This enthusiasm for and sense of ownership of the lessons they authored and tested are further illustrated in this teacher's comment:

> All the lessons I did as part of the study, I'm still doing. . . . I found them to be so valuable that I don't want to eliminate them. I think that it's providing the students with additional learning that they can really use. . . . [The lessons] are now integrated into my curriculum and will stay. I have no plan on taking them out.

Another teacher shared that he now has the confidence to teach the math-enhanced lessons when the administrator comes in to conduct his yearly evaluation:

> It works, it works! I know, that's the bottom line, it works and the kids get it. . . . I actually had a kid come up and say, 'How come we don't do this on Tuesdays anymore? I need this once a week.' Oh, my God, he's telling us he needs instruction.

This same teacher often repeats lessons multiple times throughout his program because the context calls for it and students need the reinforcement.

Following a Framework

In interviews conducted prior to the original *Math-in-CTE* pilot (Stone, Alfeld, Pearson, Lewis, & Jensen, 2005), we found that while CTE teachers often recognized the math in their curricula and made individualized attempts to address it, they had no systematic way of approaching the integration. As a part of that study, the seven elements pedagogic framework was developed and used as the primary guide for creating, teaching, critiquing, and refining the math-enhanced CTE lessons. In a follow-up interview, one teacher reflected back on the process of learning to use the framework:

> I think it was important to have been actually forced to go through these seven steps when I did the lessons, because it made you think about it. And whether you used it or not, it made you as an instructor think about each step.

In this study, we found that the experimental CTE teachers who reported teaching the lessons, not only continued to utilize the seven elements, but actually liked using the framework and considered it a worthwhile way to organize their lessons:

> I like the model. Initially it helped me to develop kind of a framework in which to, you know, initiate the lesson with the students. It helped me as far as being able to tell the students what they were going to be learning and what type of math they were going to be using and that way they felt confident that they could do it. . . . I liked the model in that it could help you kind of frame what you needed to do and what you needed to teach, organize your thoughts.

We see from this quote that the teachers also noticed that following the framework helped them better assess student progress. Elements 2 and 7 in the framework explicitly call for assessment. Many teachers we interviewed found that the elements made the actual presentation of the lesson go more smoothly, as indicated in this comment:

> Just the process of the breakdown of the seven elements as they were [developed] made it a lot easier not only to present, but for the students to absorb some of the more difficult concepts in the other classes as well as the ones presented in the lessons.

This teacher allowed students to get their hands on a task first and then he worked back through the elements in the lesson. He reported that this process increased his students' engagement.

Most of the math teachers who reported using the model were extracting the contextual examples from the lessons for use in their classes. Fewer reported using the full lessons as they were developed, which is understandable in terms of the math content they were required to cover in a course and the approach with which they taught the math. As we learned in the original *Math-in-CTE* study, math teachers typically bridged from the procedural math back to the contextual examples and reported having limited time to do so. However, one math teacher we interviewed found the framework helpful in terms of sound lesson planning. As she put it, "It helped me clarify as I set up my own lessons. . . . I actually divide it up into steps, I always have an introduction now, I always have a closing in my lesson plans . . . "

Helping Students

The teachers we interviewed frequently associated their use of the *Math-in-CTE* model with a growing awareness of its effect on the learning experience for their students and for themselves. This awareness was often reflected in the way they were making curriculum decisions, such as looking for more math in their courses, repeating lessons as needed for reinforcement of learning, and mapping the math in new courses. Some even reported that they were investigating how to integrate other academic subjects into their classes.

A CTE teacher shared how he attempts to involve students in recognizing the academics hidden in their lessons to help them see the need for learning it:

> I think that makes for a better environment of learning with the students and with me as their instructor giving them an opportunity to see that "Hey, we use this stuff, this stuff is for real" and it benefits not only me, but it benefits everybody that's involved with the project.

Utilizing the seven-element framework often provoked teachers to think about the "why" question, and subsequently to build a stronger, more authentic rationale for their overall curriculum choices, as this teacher expressed:

> I can say that after 30 years of teaching, I hadn't been doing the "why." . . . That "why" had not been there until I was involved with this experiment. And every lesson I teach,

> whether it's animal science, introduction to ag, talking about FFA, I'm always thinking now about "why".

The majority of the math teachers we interviewed talked about the importance of using the contextual examples embedded in the CTE lessons to make workplace or everyday applications of math more explicit in their instruction. They were quick to point out how the examples help them answer the "why learn math" question that surfaces in their classes. One math teacher described how the students picked up on the contextual examples and thus were better able to relate to the math in his class. He continued, "I could see their interest piqued because the question all math teachers get is *when am I ever going to use this?*"

The CTE and math teachers alike described the benefit to their students when these connections of math to the context were reinforced from both sides, as this teacher reflected:

> I've seen where it's helped the students with the connections because they hear some of the terms from me that they're also hearing in their math classrooms from the math teachers and there's no question that that reinforcement helps, it really helps.

When CTE teachers teach math in the context of CTE, they address the math required in the workplace; it's the math at the core of their CTE curriculum and students benefit. This comment by an automotive teacher aptly summarized why teachers continued to use the model:

> The kids need it. That's my answer. . . . We must increase our [state test] scores in reading and writing and mathematics. It's not an option. . . . I deal with service managers and shop owners and basically what they have told us is, teach the kids technical basics so they know the difference between a socket [wrench] and a screw driver; however, emphasize that they have to be able to read and write and do math if they're going to be successful in the shop.

How Teachers Used the Model

In the previous section, we presented the reasons for using the model that teachers reported. In this section, we shift the focus to what we learned about *how* teachers reported using the lessons, and in particular, if they continued to follow the lesson plans and the seven elements. The seven elements were not designed to be solely constrained to ordinal steps, however, the presence of each element is critical to the delivery of a math-enhanced lesson. In particular elements 3 through 5 provide for the transfer of learning, walking students from the math concept embedded in the CTE content to the traditional math example. Therefore, in our interviews, we asked the teachers to walk us through two lessons they reported teaching, so we could learn more how about how they might be adapting or changing the lessons as they continued to teach them.

Sustaining the Seven Elements

The interviews with the experimental-group CTE teachers revealed they were closely following the seven elements in the lesson plans which verified what they had reported in their mail

questionnaires. Like most teachers, they were busily adapting the lesson plans to their students' needs and to the demands of their curricula. These kinds of adaptations were mentioned in the interviews:

- Adding more of their own ideas to the lessons
- Shortening lessons to accommodate shorter class periods
- Teaching one lesson over several days
- Adjusting for the needs of special education students
- Adding games, activities
- Striving for authenticity to the context in use of different examples
- Using manipulatives

Furthermore, the interviews confirmed that the CTE teachers sustained the use of the seven elements even as they were making these adaptations. Analysis of the interview text also revealed that the teachers were developing a sense of when to adjust the lessons, not by eliminating the elements but by adjusting the activities to such factors as their students' abilities or the changing demands of the context. Many credited this increased confidence to the amount of practice they experienced during the study and to teaching the lessons on a regular basis. One teacher explained it this way, "My experience has helped me to tweak and become, I think, more effective and more efficient in how I use the lessons." For others, their increased skill and familiarity with the model had progressed to a point where the elements began to "blur" together; they said it was more difficult to identify where the CTE ended and the math began: "Ideally it's done and [the students] don't even know it, and it's just blended in and becomes an everyday thing . . . "

Adjustments to the lessons were noted most frequently in Element 4, in which contextualized examples were extended from the embedded math concept. Teachers indicated that, while they maintained Element 3, the original embedded problem, they adjusted or added examples to their lessons to better fit the immediate interests of their students, to accommodate a particular project in the lab or shop, or sometimes even to tie in a local event. One health teacher shared how practical applications were an integral part of the assignment: "They had to adjust crutches; they had to adjust a walker, a cane; they had to adjust a bed at different heights . . . "

There was also some evidence from the interviews that teachers and students alike were still struggling with Element 5, the point at which the extension of the embedded math moved into traditional math examples. It was at this juncture where teachers were challenged by their students' varying math abilities. A few teachers told us they could "lose" their students by spending too much time on the traditional math examples, so they would opt to shorten or adjust, as one teacher described:

> I didn't spend as much time using the general math examples as I did when I was part of the study, but I still did teach some of the general math. . . . The biggest difference is that I make sure that I use the math terms.

It was clear from the interviews that many of the CTE teachers continued to adjust and refine the lessons they authored in the study. Whatever adjustments were made, the teachers frequently ac-

knowledged the importance of continuing to bridge the language of CTE and math, as the teacher above indicated. On the rare occasions when teachers reported skipping elements, it was usually because they perceived that students already knew or understood the concept.

As we reported earlier, the control-group teachers were more inclined to pick and choose lessons or parts of lessons and then fit the pieces into what they were currently teaching. They were also more inclined to the select lessons with more fully developed instructional supplements. On the whole, they did not consistently follow the seven elements or include Elements 3-5 for the transfer of learning. The math teachers, while reporting that they used the model, tended to extract and adapt the contextualized examples for enhancing the more procedural math instruction in their classrooms and did not follow the seven elements.

Fit to Curriculum

As in the original study, teachers pointed to the fit of the lessons to the curriculum as a key to successful implementation of the *Math-in-CTE* model. This fit to the curriculum really began with a curriculum mapping process in the early stages of the study, whereby the CTE-math teacher teams examined the CTE curricula to find the intersection of the CTE and math concepts. In the follow-up interviews, we found that many of the CTE teachers, having internalized the model, were "seeing" more math and were engaged in a kind of ongoing "mental mapping" process.

For the purposes of the original study, in particular, to ensure that the experimental "treatment" was implemented, the teachers taught all of the lessons within one academic year[2]. After the experiment ended, teachers were free to use the lessons as they chose, and we found that they placed them across multiple courses/programs when the curriculum addressed the particular concepts covered, sometimes repeating the same lessons more than once in a course. "I picked the [lessons] this year that fit with the curriculum," explained one teacher. "I did four lessons this year and I'll do the rest of them next year because they fit better in the curriculum next year." Another teacher described it this way:

> When I teach a lesson it has to fit. . . . If you're talking electricity and electronics, there comes a time when you have to use Watt's law to calculate them and almost immediately when we started the school year I had a student who had a sound system put in his car and basically what was happening is that he was having problems with the battery dying . . . so what better time, you know?

Once lessons were introducted into their curriculum, teachers refined them for a better fit and even wrote new ones as they sought ways to maximize their opportunities to teach math. This teacher described the process:

> After being a part of the study, I definitely became more aware of being able to pull math out of my regular curriculum that I teach. So I was spending a lot more time thinking

2 To monitor the teaching of the lessons, the math teachers submitted reports of pre-teaching meetings with their CTE teachers, and the CTE teachers submitted post-teaching reports after they had taught the lessons.

> about math and how I could use what I learned in the study and to incorporate that or embed that in the lessons that I currently teach. So I've definitely become more aware of it and I've looked at the resources that I've gained from being on the study and I've looked at the lessons that other teachers prepared and have looked at placed where I could fit those lessons and/or bits and pieces of those lessons into my curriculum.

As was the case in the original study, teachers reported struggling with the issue of time. It was the issue of the "tipping point." How much math can be injected into the curriculum without losing the integrity of the CTE content and the time to teach it? Most of the teachers negotiated this through adjusting the lessons and finding the optimum fit to their curriculum. However, we interviewed one teacher who disclosed that she was teaching only parts of lessons because of time. "I think the model was just too overwhelming as far as time. When I would spend a class plus maybe some of another class on one lesson, it was too much."

While time remained a barrier for some, the predominant view of the teachers was found in this quote, "It's made the core of my curriculum. . . . I find myself using them as a starting spot because . . . they drive home what we're trying to teach in [CTE courses in this state]." Another shared, "[Using the lessons] is going to be an ongoing process for me for as long as I am teaching."

In the follow-up interviews of the teachers who continued using the model, we found that their participation in the *Math-in-CTE* study and use of the model had become internalized in a way that influenced their thinking about the content and curriculum of their courses and their teaching practice in general. The bottom line for most teachers was the well-being of their students. Their effort in sustaining the model was best captured by this teacher:

> I feel like it's a win-win situation for the students and for me and it's made me more aware. Math is definitely built into my curriculum and I need to bring it out more because it's going to help the students overall.

Teachers Not Using the Model

While a majority of teachers who participated in the *Math-in-CTE* study continued using the model, not all chose to do so. In this section, we present an analysis of the telephone interviews conducted with CTE teachers who indicated that they were not explicitly teaching mathematics and math instructors who indicated that they were not using the seven-element approach or any applications from the math-enhanced lessons. As was reported in Chapter 2, the interviewers were only able to reach about half of these teachers. Consequently, the themes and quotes from teachers presented in this section may not be representative of all those not using study materials. All of the teachers who were interviewed verified the reasons they had reported in the mail survey for not using lessons from the study, and some explained their answers in more detail.

Time

As indicated in the surveys, the most common reason cited in the interviews for not using the model was lack of time, due primarily to the amount of the course content they were obligated to cover. This tension was articulated in these interviews much as it was in the original math study—as a matter of balance between the need to complete essential curriculum against the need to integrate curriculum, as these three teachers described:

> You know the time piece, again, getting through content, trying to balance that with integrating different concepts. Yeah, I had some trouble with that. And to be honest, there were times where I really didn't even think about those CTE lessons for three weeks, four weeks. . . . Some of that was just kind of forgetting about it, getting caught up in other things that you want to get done before the end of semester and things you want to cover.

> I am fitting one year's worth of curriculum into two-thirds of a year, and consequently, each semester was shortened by approximately 20 hours. So, I just had to cut things left and right. As far as presenting the whole lessons, this year, I just haven't had the time to do that.

> It's pretty much, I don't have the time. There's so much curriculum in my class that I need to teach and quite frankly I didn't even get to all of it this year and it kind of bothers me. There are some articulation agreements, things that I'm trying to uphold and for some reason this year it was particularly hard to cover everything in the curriculum.

Fit to Curriculum

The importance of the fit of the math-enhanced lessons and materials to existing curriculum was articulated by the CTE and math teachers who continued using the model or its applications. Teachers participating in the original study also identified this as a key factor in successful implementation. While this reason was not provided among the alternatives on the mail survey, the teachers not using the model also noted this in their interviews with some frequency. Mathematics teachers of higher-level courses gave this reason, as did several of the CTE teachers. For instance, a teacher noted that the math-enhanced health lessons had been developed for the first-year core curriculum. In the year following the study, many of the health teachers had second-year students who spent most of their school year in internships. Two health teachers gave these reasons for not using the lessons:

> The course I teach is laboratory-oriented and the math required for this course is above and beyond the lessons covered in the CTE project. The CTE math project, lesson plans were for Certified Nursing Assistant programs and [Occupational Therapy and Physical Therapy] programs.

> I guess because [I teach] dental assisting I don't, I mean, some of the math lessons don't really lend themselves to my curriculum.

Sustaining Contact

The professional development that the experimental CTE and math teachers in the *Math-in-CTE* study experienced led to the emergence of a community of practice within each of the occupational areas. In the follow-up interviews with the teachers who did not continue to use any lessons or methods, we asked if they had continued contact with those whom they had worked with in the study. The answers were mixed: some reported ongoing contact, but just as many said that they had limited or no contact.

The interviews with teachers among the experimental group who reported limited contact suggested that this was primarily due to proximity and a continuation of the limited contact that occurred during the study. One math teacher who was interviewed noted, "I would see him in the hall every now and then. But his building is . . . so far away." He rarely saw the CTE teacher because the CTE classroom was not adjoined to the school's main campus.

This CTE teacher commented on the challenges of staying in touch with the math partner who was located in a different school:

> It's not like she was hard to get a hold of, I mean, through e-mails or voice mails, and had I been more assertive on my end I could have figured out what I needed to figure out from her, you know. It would be easier if the person was in the building, but at the same time I think that can become an excuse as well, because there are ways to communicate with people, especially through e-mail that make it something that could definitely work.

During the original *Math-in-CTE* study, the control teachers did not work with math teacher partners. In these follow-up interviews, we asked them if they could consult math teachers in their schools if they needed assistance. Here again, the responses were mixed. This teacher indicated that he had not asked for the support of a math teacher partner and doing so would likely require the assistance of an administrator to get things started:

> Um, I think if the principal, the superintendent or administration was to come to me and say hey, can you do something to teach your math better, I would say yeah, this study suggests that I hook up with a math teacher and then, and I would be for doing that.

Bits and Pieces

The interviews revealed that a negative response to the mail survey did not necessarily mean that the teacher was not using parts of the lessons or was somehow in disagreement with the model. For example, one of the control teachers had indicated on his mailed questionnaire that he was not using the lessons from the study. During the telephone interview, however, it became apparent that he was taking some of the content from these lessons to develop lessons of his own and was involving a math teacher in his school, as he explained here:

> We have a math teacher here. We actually have two full-time math teachers that rotate between all the different shops. I sat down with her some and we went over [the *Math-*

> *in-CTE* lessons] and I took out some of the stuff that I just thought was more than what I needed. Cleaned them up to my liking a little bit and that's what I'm using.
>
> She [the math teacher] will do what she has to do to help you out. We've been trying to stay a lot closer in touch. She will ask, "What are you working on?" If I'm doing engines, then she'll do the math lesson on figuring compression ratios or bore strokes, things like that.

During the follow-up interviews, several of the math teachers who had reported that they were not using anything from the study noted that their normal teaching approach has many similarities to the seven-element pedagogy of the study. When asked to elaborate on his response, one math teacher commented, "I actually have used that method even before we started the CTE study lessons." Another specifically referenced used of the elements: "Well I think all good teachers try to provide, use those seven elements. I think that's part of our natural teaching process is we're teaching students the way that we believe is the right way to do it."

Other Reasons

The teachers interviewed provided a variety of other reasons for not using the lessons or applications in their courses. Several of the control CTE teachers said they did not teach any math-enhanced lessons because they never received the lesson CD for their occupational areas.[3] Other reasons given by the teachers included:

- Another teacher at the same school taught the lessons to most of the same students
- The academic subject emphasized in the CTE class was English
- No math partner
- Students were seniors serving apprenticeships at auto dealers
- Teaching colleague abruptly left the school and the teacher had to take over his classes

When one math teacher was asked if she liked the approach, she replied, "I can't even remember the seven steps." An interview with one control CTE teacher indicated a deliberate choice not to use the model, as he shared here:

> With the way that I teach my class and the kind of students that I have, it seems to work better for me and the students not to just put math in their face.

Future Use

Some teachers who said they did not teach the lessons the year following the study planned to do so the next school year. These teachers typically elaborated on the specific lessons

3 When the experimental intervention ended, control teachers were mailed a lesson CD and offered optional training sessions. Only 16 of the 40 control teachers who returned mail questionnaires indicating they were not teaching explicit math reported that they had received the CDs. It seems unlikely that so many CDs were not delivered, since the CDs were sent to the addresses to which the questionnaires were mailed and none of the CDs or mail questionnaires were returned as undeliverable. The teachers may have said that they had not received the CD because it was an "acceptable" reason for not using the lessons.

they were considering or the influences in their state or school that were pushing them to include more math. Here are two examples of such comments:

> Using math in CTE to me has a big future in [state]. We are going to have some real major trouble trying to get our level of mathematics up to the regular schools' math levels, and so next year I plan on doing a lot of work in trying to integrate the math at a higher level into our CTE programs.

> We're going to call it curriculum rewrite. I went through all our stuff, all my lessons and we're going to put math lessons in with them. We're following the CTE model, like the ones we saw in the CTE study, that lesson plan outline. The school has pretty much [made it] mandatory this year that everyone had to do at least four math lessons in that model, and then we have to put them in with our [regular lessons]. When I do my electrical I used the one on Ohm's law. I have that in with that and that'll be part of my curriculum, basically.

Concluding Comments

The teachers not using the model were asked if they had any final comments they would like to get on the record. Most of the comments that were made concerned the value of the study and the teachers' appreciation for being involved in it. This was true for the control as well as the experimental teachers. Below are the final comments of four teachers:

> I think the study was great. I appreciate and understand what was going on with it and being part of the control group I understand my aspect of it, not trying anything new during that time, just keep teaching the way I have. We need to teach the kids more math, but they need to be able to apply it to their lives. Our state is raising math standards and math requirements to graduate. I think this is doing an injustice, because the math that they are requiring these kids to take, most of these kids won't ever use it again in their life. Just to teach math to teach math is a little overkill, when we should be teaching math that these kids can apply to their life in the business world.

> It was valuable, definitely valuable for, for us. I think that it enriched the lessons that I had to teach because it was all reinforcing the content that we were already teaching and that was the biggest benefit. I felt like it was a bonus and, and the fact that we saw significant gains, [in test scores] just drives that point home. I just feel like we need common prep time or more time for planning. And then I think as a state we need to provide training [in the study's approach] for those that didn't get it.

> There were a couple of times when it was tough, those all-nighters [developing lessons] but not only just for the content that we got from the whole experience, but the camaraderie and the friendship, it was just one of those magical things.

> The only thing that I have now is with this No Child Left Behind thing going on and, of course, [state] requirements for math and science. Is there a way that what we've learned here can be used to help career tech teachers maintain their courses because I think that is going to be a question.

All of these comments were from teachers who for a variety of reasons did not use any of the materials after the study ended. For these teachers, at least, their decisions not to use the materials were not a rejection of the goals or pedagogy of the study, but the result of other influences on them and their classes.

Summary

The quantitative analysis of the mail survey in the previous chapter indicated that a majority of the experimental teachers were using the model and a majority of the control teachers were not. This chapter presented qualitative analyses of the personal and telephone interviews which followed up on the survey.

The interviews with those who continued using the model revealed that the experimental group CTE and math teachers had internalized the model in a way that had changed their overall approach toward teaching. For the CTE experimental teachers, this was expressed in the ways that they had embraced the model and were "seeing" the math across their curricula. It was expressed by the math teachers as a more generalized change in their overall teaching approach. Such changes were conspicuously absent in the interviews with the control teachers, whose descriptions revealed a struggle to use the lessons and materials in a systematic way.

The teachers who continued using the model told us they did so because "it worked" and ultimately helped their students learn more math. They liked following the seven-element pedagogic framework and considered it to be an effective organizer. The interviews also revealed that the experimental group CTE teachers continued to closely follow all seven elements of the framework, particularly Elements 3-5, where the transfer of learning was addressed. Adaptations and adjustments they made did not interfere with the integrity of the framework. In contrast, the control teachers did not maintain the integrity of the model as they used the lessons and materials. Analysis of their interviews indicated they were utilizing selected parts of lessons and the instructional materials with which they were most comfortable teaching or perceived to be most needed. Math teachers primarily pulled out the contextualized examples to support their math instruction, although some reported using the framework as an organizer for teaching. As in the original *Math-in-CTE* study, the interviews revealed the importance of finding the best fit of the math-enhanced lessons and materials with the curriculum.

Interviews with teachers who reported not using the model yielded a wide variety of responses. Among the most common reasons given were lack of time and poor fit to the courses they were currently teaching. Interestingly, many reasons teachers gave for not using the model were laced with affirmative comments and did not represent an overt rejection of the model. A number of teachers reported using bits and pieces of the model and some indicated that they planned to use the lessons and materials in the future as conditions changed.

CHAPTER 5: DISCUSSION AND IMPLICATIONS

Almost three-fourths (73%) of the experimental CTE teachers and two-thirds (66%) of the math teachers continued to use methods and materials from the *Math-in-CTE* study in the school year that followed the experimental intervention. In light of the literature on the difficulties of sustaining change in education reviewed in Chapter 1, we consider these to be fairly impressive findings, but are they? We could find in the literature no studies comparable to the one presented in this report—experimental studies that had followed up with participating teachers to determine how many continued using the instructional interventions that the studies had tested. We searched the ERIC database using different combinations of the terms *sustaining*, *continuing*, *experiment*, *methods*, *teachers*, and *follow-up*,[4] and found several follow-ups of students who had participated in experiments, but none of teachers. The closest we came was a follow-up of schools, not teachers, who implemented various school reform models.

The Southwest Educational Development Laboratory (2003) surveyed 288 schools in its five-state service area that had received funding under the Comprehensive School Reform Demonstration program two years after their funding had ended. Forty percent of the schools (106) returned questionnaires with 79 reporting that they had continued all or at least half of the reforms they had implemented, and 29 reporting that they had not. This represents a 75% continuation rate, essentially the same as for our experimental teachers. If we make the same assumption about those who did not respond to the Southwest Lab survey that we made for our teachers—that those who did not respond were not continuing—the percentage of those continuing the reforms drops to only 27%. If we make the less draconian assumption that half of the 182 who did not return questionnaires were not continuing, the number continuing increases to 59%. We repeat: this was a study of schools, not teachers, and of whole school reform models, not instructional methods. Nevertheless, it provides a perspective that supports our optimism about our findings.

The interviews we conducted with the teachers who continued to teach explicit mathematics were also encouraging. As discussed in Chapter 4, some of these teachers reported that their participation in the study had influenced or changed their approach to teaching. They had internalized the seven-element pedagogy to the extent that they approached virtually all their teaching from this perspective. Such a change was not true of all teachers, of course. About one-fourth of the experimental teachers did not continue to use the pedagogy or the lessons with the most common reasons given being lack of time and lack of fit between the lessons and their curriculum. Lack of fit was especially true of health teachers, since the health lessons had been designed to fit into the first-year core curriculum and in the year of the follow-up many of the teachers were supervising second-year students in internships.

It bears repeating that our rates of continued use of the experimental materials were achieved with teachers who responded to our recruitment and participated for the full duration of the study. These teachers were self-selected and in all likelihood more open to change and motivated to improve their teaching than teachers who had not volunteered. During the experiment,

4 The search was conducted February 23, 2007 at www.eric.ed.gov.

they had the support of the project staff and their fellow volunteers, but they did not have what is repeatedly reported as a key to successful educational change: supportive principals (e.g., Hargreaves and Fink, 2006). Their principals were aware of their participation in the study, but they were not active members of the communities of practice. If our experimental teachers had been in schools with other teachers who had received the same professional development and were actively supported by their principals, we think we would have found even higher rates of continued use.

Given that the experiment yielded meaningful differences in learning and that most of the teachers who participated continued to use the method and materials, what are our recommendations to those who may want to try our approach? Rather than a set of "ivory tower," difficult-to-implement recommendations, we offer a scenario of a possible future and then discuss its likelihood of becoming a reality.

A Possible Future

John Hughes, the CTE director of Big City Public Schools, is pleased. The math scores of his students have been improving. In the 2012 statewide testing, the average score for his students was only 3% below the average for the whole system. In 2007, when he had begun a new initiative to improve their scores, they had been 15% lower. That year NCLB had been reauthorized, increasing the pressure on the Big City school system to show adequate yearly progress. Prior to 2007 Hughes had provided some computer-based remediation and pull-out classes for students doing poorly in their academic courses, but scores on the yearly tests had not improved.

At the 2006 meeting of his state CTE association, he heard a presentation by David Smith, a professor who had taken part in a study that enhanced mathematics instruction in CTE classes. He contacted the professor and asked him to lead a one-day professional development workshop for his teachers. Smith responded that all he could do in one day was give an overview of the pedagogy and professional development used in the study. Smith told Hughes that if he really wanted to replicate the study, his district would have to form a district leadership team to lead the initiative and recruit teams of CTE and mathematics teachers who would agree to work together for a full academic year and take part in ten days of professional development.

Ten days of professional development was an awful lot, but Hughes knew that Big City's high percentage of students eligible for free and reduced lunch qualified it for considerable funding from both Perkins and NCLB. He also knew that his state's plan for the use of its Perkins grant promised to deliver "comprehensive professional development that integrates academic and CTE content standards." Perhaps he could tap into some of that money.

Hughes met with his superintendent and discussed his ideas for implementing what the professor had recommended. Demonstrating adequate yearly progress was the superintendent's top priority and she liked what she heard. She also was well aware of the difficulties of implementing large-scale change in her district. She asked Hughes to put together a proposal for a pilot test of the methods he was proposing. She promised Hughes that if he obtained a grant from the

state's Perkins grant, she would find funds to match it.

Encouraged by this response, John contacted Professor Smith and asked him to serve as consultant on the development of a proposal for the state department of education. Smith asked Hughes to recruit two CTE and two math teachers to assist in the development of the proposal. Smith came to Big City and worked with Hughes and the teachers to prepare the proposal. They decided to focus on the two occupational areas with the most teachers in the district: business and health. This allowed them to recruit ten CTE teachers in each area and to match them with mathematics partners.

Their proposal requested funds to pay Professor Smith and one assistant to provide technical assistance in the professional development the teachers would receive. The budget included funds to cover the cost of bringing the teachers together, a $100/day stipend for the teachers when the workshops occurred on non-school days, and pay for substitute teachers when the workshops occurred on school days. The proposal also asked the state department of education to assign a CTE supervisor and a mathematics supervisor from its staff to assist in the professional development.

The state department funded the proposal in March 2007, and Hughes began recruiting CTE teachers to participate. He sent out an announcement about the new initiative to all the teachers in the two selected CTE areas and invited them to apply to participate. The announcement described what would be asked of those who volunteered: ten days of professional development throughout the year, beginning with one week during the summer of 2007, writing of lesson plans, and teaching all the lessons developed for their occupational areas. His initial announcement drew applications from about half of the desired ten teachers per area. Hughes met individually with those who applied and asked them to encourage colleagues to apply. He also asked them to recruit math teachers to work with them. Only about one-third knew math teachers who were interested, so Hughes worked with the district math supervisor to recruit the rest.

In July 2007, the 40 teachers—20 CTE and 20 math—came together for professional development. They met as a full group to receive an overview of the pedagogic model they would be using. After their initial briefing, the CTE teachers and their math partners separated into their two occupational areas. The first thing they did was map the CTE curricula to identify math that naturally occurs in it—i.e., math that is essential to the occupational skills being taught. Each group identified math concepts that met this definition. Each of the CTE and math teacher teams selected one or two of the concepts and worked together to develop a lesson plan to teach that concept within its occupational context. Within each occupational area, each team presented a draft of its lesson to their colleagues for their feedback and used a critiquing rubric to revise the lesson. The CTE teachers then individually decided when they would teach the lessons that had been developed during the coming (2007-08) school year. While working with their CTE partners, the math teachers identified many examples of applications of mathematics that they could use in their own classes.

During that school year, the CTE teachers taught the lessons. They met with their math partners before teaching them to review concepts and obtain suggestions for presenting the mate-

rial. All the teachers came together during the fall and spring semesters for two-day "refresher" workshops to report on the lessons they had taught and the students' responses. The CTE-math teams that had developed each of the lessons used this feedback to revise them.

The students who received these lessons took standardized math tests to assess their effect. Post-test scores were 7-10% higher than the pre-tests. Armed with this evidence, Hughes received approval and funding to expand this approach to other occupational areas. Hughes and his district team recruited additional teachers in each of his occupational areas and invited the CTE and math teachers who had taken part in the pilot to provide leadership to these new groups. He continued the five-day workshops during the summer and the two-day "refreshers" during the school year.

After five years, all of the teachers who were receptive to the new approach had taken part in the professional development and the effects of explicit math instruction were being seen in the statewide tests. Working together to develop the lessons had given both the CTE and math teachers increased respect for what their colleagues were teaching. The CTE teachers reported that explicit math instruction was helping their students to learn the technical skills better. The students understood the concepts rather than just rules to apply. The math teachers had more "real world" applications to answer the perennial question, "How am I ever going to use this?"

Back to the Present

The scenario is optimistic, but not utopian. The first year of the scenario follows our experiences in conducting the *Math-in-CTE* study closely. We have cited the literature on the difficulties of sustaining and expanding educational innovations, but there is reason for optimism. The follow-up of the teachers presented in this report found high continuation rates even without the support of the communities of practice that the experiment had provided. If these communities had continued, it seems likely that even more teachers would have continued to use the materials. With regard to expansion, as this is written we are working in three states and a large urban district to replicate the methods used in the study, and we have received many more inquiries from states and districts that want to try the *Math-in-CTE* approach.

From the qualitative data we collected as part of the *Math-in-CTE* study, we extracted five factors, which we labeled "core principles," that we consider critical to its success:

1. Develop and sustain a community of practice among the teachers.
2. Begin with the CTE curriculum, not the math curriculum.
3. Understand that math is an essential workplace skill.
4. Maximize the math in the CTE curriculum.
5. Recognize that CTE teachers are teachers of math in CTE, and not math teachers (Stone et al., 2006, p. 69).

The order in which the principles are listed reflects our judgment of their importance. A group of CTE and math teachers working together within the same occupational area and focused on the improvement of instruction is the essential condition for replication of this model. Starting with

the CTE curriculum is second in importance. If CTE is not the starting point, integration will, in all likelihood, be forced. Starting with CTE also signals the value of its content. In a good CTE program, the curriculum responds to the labor market—the skills taught are those students will need if they enter the occupations they study. Among these skills is mathematics, which is the third core principle. Understanding of mathematics is not needed just to pass tests; it is required to perform jobs.

The fourth principle encourages teachers to reinforce math whenever it occurs. After a lesson on a particular concept has been presented, the math covered in that lesson may emerge several times. Teachers can use these occasions to remind students of the concept and its application in multiple settings. The auto technology teachers who participated in the *Math-in-CTE* study told us that they taught a lesson on conversion of English to metric measurement early in their programs because their curriculum often involves such conversions. Each occupational task that required a conversion provided an opportunity to reinforce the underlying math.

The final principle speaks directly to the Johnson et al. (2003) definition of integration. The CTE curriculum is a platform for instruction in an academic skill, but it does not attempt to replace academic instruction. In the best of all worlds, the academic curriculum is also a platform for instruction in the skills it teaches that are needed in the CTE curriculum. A few of the high schools studied by Johnson et al. had such dual platforms, but they are rare. In virtually all high schools, if any integration takes place, it occurs in the CTE classroom.

The *Math-in-CTE* approach affects the academic classroom only indirectly. Two-thirds of the math teachers who had worked with the CTE teachers to develop the lesson plans told us that they had adopted examples of the application of mathematics from the lessons for their classrooms. This is not the planned, systematic approach that Johnson et al. (2003) define as true integration, but it is a start and perhaps the most that can be achieved without threatening the grammar/core of schooling (Elmore, 1996; Tyack & Tobin, 1994) to the point that there is little chance that the innovation will continue.

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APPENDIX A
Mail Questionnaire, Mathematics Teachers

ID # _____

MATH-IN-CTE MATHEMATICS TEACHER FOLLOW-UP

We appreciate your willingness to assist us with this follow-up survey. Please mark each response in the box provided. If marking "other", the lines are provided for you to clarify your answer. Thank you.

1. Are you teaching mathematics classes this school year (2005-06)?

❑ Yes, please answer the question below ❑ No, Skip to Section B

2. Have you included any of the methods or examples from the lessons developed for the Math-in-CTE study in your mathematics classes?

❑ Yes, please answer the questions in Section A ❑ No, Skip to Section B

Section A

To be completed if you include methods or examples from the lessons developed for the Math-in-CTE study in your classes

A1. Have you used any occupational examples of the applications of math from the Math-in-CTE lessons in your classes?

❑ Yes ❑ No

a. Please list the occupational examples you have used: _____
_____
_____

A2. Have you adopted any parts of the 7-element teaching approach—that is, going from specific occupational applications to the general math underlying the applications in your math classes?

❑ **Yes** ❑ **No**

a. What parts have you adopted? _____
_____
_____

A3. During the current school year, does the CTE instructor with whom you worked during the research ever contact you to review the teaching of math concepts?

❑ **Yes** ❑ **No**

a. If you have any contact with CTE instructors, how frequent is it?

❑ **Less than once a month or less**
❑ **Once a month**
❑ **Once every two or three weeks**
❑ **About once a week**
❑ **Almost every day**

A4. During the current school year, do other CTE instructors contact you to review the teaching of math concepts?

❑ **Yes** ❑ **No**

a. If you have any contact with CTE instructors, how frequent is it?

❑ **Less than once a month or less**
❑ **Once a month**
❑ **Once every two or three weeks**
❑ **About once a week**
❑ **Almost every day**

BY COMPLETING AND RETURNING THIS QUESTIONNAIRE, I AGREE TO PARTICIPATE IN AN INTERVIEW CONCERNING THE METHODS OR MATERIALS FROM THE MATH-IN-CTE LESSONS THAT I HAVE USED IN MY CLASSES.

Section B

To be completed if you have NOT used any of the methods or examples from the lessons developed for the Math-in-CTE study in your classes.

B1. If you are not teaching math courses this school year, please indicate why not.

- ❑ No longer teaching, changed careers, retired
- ❑ Have non-teaching position: counselor, administrator, etc.
- ❑ Am not teaching math courses
- ❑ Other (please describe) _____

_____

_____

B2. If you are teaching math courses but are not including anything from the Math-in-CTE lessons, please indicate your reasons. (Check all that apply.)

- ❑ Occupational examples too specific, my students do not have background needed to understand applications
- ❑ Math-in-CTE examples do not fit in my curriculum
- ❑ Curriculum too full already, cannot bring more material in
- ❑ Math in these lessons is not at a level appropriate for my classes
- ❑ Do not have access to CTE teacher to provide background/support on using occupational examples
- ❑ Other (please describe) _____

_____

_____

BY COMPLETING AND RETURNING THIS QUESTIONNAIRE, I AGREE TO PARTICIPATE IN AN INTERVIEW CONCERNING REASONS WHY I HAVE NOT INCLUDED ANYTHING FROM THE MATH-IN-CTE LESSONS IN MY CLASSES.

APPENDIX B
Mail Questionnaire, CTE Control Teachers

ID # _____

MATH-IN-CTE CONTROL TEACHER FOLLOW-UP

We appreciate your willingness to assist us with this follow-up survey. Please mark each response in the box provided. If marking "other", the lines are provided for you to clarify your answer. Thank you.

1. **Did you attend the summer 2005 workshop which provided the teachers who were in the control group an overview of the methods and lessons used in the Math-in-CTE study?**

   ❑ Yes ❑ No

2. **Did you receive a CD with copies of the lessons that were developed for your occupational area?**

   ❑ Yes ❑ No

3. **Have you taught career and technical education (CTE) courses that prepare students for employment this school year (2005-06)?**

   ❑ Yes, Please answer the question below ❑ No, Skip to Section B

4. **Have you included any *explicit mathematics instruction* that was designed to teach the concepts inherent in these CTE courses? *Explicit mathematics instruction* means going beyond specific occupational applications to explain the general math concepts that underlie the applications.**

   ❑ Yes, Please answer the questions in Section A ❑ No, Skip to Section B

Section A

To be completed if you include explicit mathematics instruction in your CTE courses

A1. What approach have you used to teach the mathematics?

- ❑ 7-element approach that was tested in the Math-in-CTE study
- ❑ CORD Applied Mathematics materials
- ❑ MAC (Math Across the Curriculum)
- ❑ State-developed/approved materials
- ❑ District/school specific materials
- ❑ Other (please describe) _____

_____

_____

A2. Why are you explicitly teaching math in your courses? (Please check any that apply.)

- ❑ I recognize the value of this approach
- ❑ I have the knowledge/confidence to teach math
- ❑ Math instruction improves my courses, better prepares students for jobs
- ❑ School/district requires math instruction in all courses
- ❑ Other (please describe) _____

_____

_____

A3. During the current school year, do you ever meet with a math instructor with whom you review the teaching of math concepts?

❑ Meet with a math instructor ❑ No contact with a math instructor

a. If you have contact, how frequent is it?

- ❑ Less than once a month
- ❑ Once a month
- ❑ Once every two or three weeks
- ❑ About once a week
- ❑ Almost every day

A4. Have you taught or do you plan to teach any of the math-enhanced lessons that were developed for the Math-in-CTE study?

❑ Yes, please answer the questions below ❑ No

a. How many of these lessons have you taught, and how many do you plan to teach in the remainder of the school year?

Have already taught _____ Plan to teach _____

b. To what extent did you modify or change the lessons that you taught?

❑ I modified or changed every lesson.
❑ I modified or changed most of the lessons.
❑ I modified or changed about half of the lessons.
❑ I modified or changed a few of the lessons.
❑ I did not modify or change any of the lessons.

c. If you made modifications or changes to the lessons, why did you do so? Please describe in some detail: _____
_____
_____

A5. Have you used or do you plan to use *parts* of the math-enhanced lessons *(but not the whole lesson)* in any of your classes?

❑ Yes ❑ No

a. How many classes with parts of the math-enhanced lessons have you taught, and how many do you plan to teach in the remainder of the school year?

Have already taught _____ Plan to teach _____

Please complete the attached chart (following Section B) indicating all explicit math-enhanced lessons you have taught or plan to teach this school year. List all such lessons. Do not limit the list to lessons developed for the Math-in-CTE Study.

Section B

To be completed if you have NOT included explicit mathematics instruction in your CTE courses.

B1. If you are not teaching CTE courses that prepare students for employment this school year, please indicate why you are not doing so.

- ❑ No longer teaching, changed careers, retired
- ❑ Have non-teaching position: counselor, administrator, etc.
- ❑ Am teaching non-CTE courses
- ❑ Am teaching CTE courses that do not prepare students for employment
- ❑ Other (please describe) _____

_____

_____

B2. If you are teaching CTE courses that prepare students for employment, but are not including explicit instruction in mathematics, please indicate your reasons. (Check all that apply.)

- ❑ Do not have time, too much occupational content to cover
- ❑ Do not have the background/experience to teach math
- ❑ Do not think it appropriate to attempt to teach math in my classes
- ❑ Do not have access to mathematics teacher who could provide support in teaching math
- ❑ Other (please describe)_____

_____

_____

BY COMPLETING AND RETURNING THIS QUESTIONNAIRE, I AGREE TO PARTICIPATE IN AN INTERVIEW CONCERNING REASONS WHY I HAVE NOT INCLUDED EXPLICIT MATH INSTRUCTION IN MY CTE CLASSES.

ATTACHMENT (Section A)
To be completed if you included explicit mathematics instruction in your CTE courses

2005	Course/Unit	Math-Enhanced CTE Lessons	Math Concepts Embedded in Lesson
Sep			
Oct			
Nov			
Dec			
2006			
Jan			

PLEASE TURN TO OTHER SIDE

2006	Course/Unit	Math-Enhanced CTE Lessons	Math Concepts Embedded in Lesson
Feb			
Mar			
Apr			
May			
Jun			

BY COMPLETING AND RETURNING THIS ATTACHMENT, I AGREE TO PARTICIPATE IN AN INTERVIEW CONCERNING THE EXPLICIT MATH INSTRUCTION I INCLUDE IN MY CTE CLASSES.

APPENDIX C
Mail Questionnaire, CTE Experimental Teachers

ID # _____

MATH-IN-CTE EXPERIMENTAL TEACHER FOLLOW-UP

We appreciate your willingness to assist us with this follow-up survey. Please mark each response in the box provided. If marking "other", the lines are provided for you to clarify your answer. Thank you.

1. Have you taught career and technical education (CTE) courses that prepare students for employment this school year (2005-06)?

❑ Yes, Please answer the question below ❑ No, Skip to Section B

2. Have you included any *explicit mathematics instruction* that was designed to teach the concepts inherent within these CTE courses? *Explicit mathematics instruction* means going beyond specific occupational applications to explain the general math concepts that underlie the applications.

❑ Yes, Please answer the questions in Section A ❑ No, Skip to Section B

Section A

To be completed if you include explicit math instruction in your CTE courses

A1. What approach have you used to teach the mathematics?

❑ 7-element approach that was tested in the Math-in-CTE study
❑ CORD Applied Mathematics materials
❑ MAC (Math Across the Curriculum)
❑ State-developed/approved materials
❑ District/school specific materials
❑ Other (please describe) _____
_____

A2. Why are you continuing to explicitly teach math in your courses? (Please check all that apply.)

- ❑ I recognize the value of this approach
- ❑ I have the knowledge/confidence to teach math
- ❑ Math instruction improves my courses, better prepares students for jobs
- ❑ School/district requires math instruction in all courses
- ❑ Other (please describe) _____

_____

_____

A3. During the current school year, do you have any contact with the math instructor with whom you worked during the study or a different math instructor *to review the teaching of math concepts*?

- ❑ No contact with math instructors to review teaching of math
- ❑ Contact with instructor with whom I worked
- ❑ Contact with different math instructor

a. If you have contact, how frequent is it?

- ❑ Less than once a month
- ❑ Once a month
- ❑ Once every two or three weeks
- ❑ About once a week
- ❑ Almost every day

A4. Have you taught or do you plan to teach any of the math-enhanced lessons that were developed for the Math-in-CTE study?

❑ Yes, please answer the questions below ❑ No

a. How many of these lessons have you taught, and how many do you plan to teach in the remainder of the school year?

Have already taught _____ Plan to teach _____

b. To what extent did you modify or change the lessons that you taught?

- ❑ **I modified or changed every lesson.**
- ❑ **I modified or changed most of the lessons.**
- ❑ **I modified or changed about half of the lessons.**
- ❑ **I modified or changed a few of the lessons.**
- ❑ **I did not modify or change any of the lessons.**

c. If you made modifications or changes to the lessons, why did you do so? Please describe in some detail: _____
_____
_____

A5. Have you used or do you plan to use *parts* of the math-enhanced lessons *(but not the whole lesson)* in any of your classes?

❑ **Yes** ❑ **No**

a. How many classes with parts of math-enhanced lessons have you taught, and how many do you plan to teach in the remainder of the school year?

Have already taught _____ **Plan to teach _____**

Please complete the attached chart (following Section B) indicating all explicit math-enhanced lessons you have taught or plan to teach this school year. List all such lessons. Do not limit the list to lessons develop for the Math-in-CTE Study.

Section B

To be completed if you have NOT included explicit mathematics instruction in your CTE courses.

B1. If you are not teaching CTE courses that prepare students for employment this school year, please indicate why you are not doing so.

- ❑ No longer teaching, changed careers, retired
- ❑ Have non-teaching position: counselor, administrator, etc.
- ❑ Am teaching non-CTE courses
- ❑ Am teaching CTE courses that do not prepare students for employment
- ❑ Other (please describe) _____

_____

_____

B2. If you are teaching CTE courses that prepare students for employment, but are not including explicit instruction in mathematics, please indicate your reasons. (Check all that apply.)

- ❑ Do not have time, too much occupational content to cover
- ❑ Do not have the background/experience to teach math
- ❑ Do not think it appropriate to attempt to teach math in my classes
- ❑ Do not have access to mathematics teacher who could provide support in teaching math
- ❑ Other (please describe)_____

_____

_____

BY COMPLETING AND RETURNING THIS QUESTIONNAIRE, I AGREE TO PARTICIPATE IN AN INTERVIEW CONCERNING REASONS WHY I HAVE NOT INCLUDED EXPLICIT MATH INSTRUCTION IN MY CTE CLASSES.

ATTACHMENT (Section A)
To be completed if you include explicit mathematics instruction in your CTE courses

2005	Course/Unit	Math-Enhanced CTE Lessons	Math Concepts Embedded in Lesson
Sep			
Oct			
Nov			
Dec			
2006			
Jan			

PLEASE TURN TO OTHER SIDE

2006	Course/Unit	Math-Enhanced CTE Lessons	Math Concepts Embedded in Lesson
Feb			
Mar			
Apr			
May			
Jun			

BY COMPLETING AND RETURNING THIS ATTACHMENT, I AGREE TO PARTICIPATE IN AN INTERVIEW CONCERNING THE EXPLICIT MATH INSTRUCTION I INCLUDE IN MY CTE CLASSES.

APPENDIX D
Instructions for Randomly Selecting Two Lessons for Personal Interview

We will use 1 die to select the lessons on which the personal interviews with each teacher will focus. The rule is that all lessons listed by a given teacher should have an equal chance of being selected for the interview. The following steps will ensure that this occurs. We cannot use 2 dice, because numbers in the middle of the distribution form have a higher frequency of occurring than numbers at either end. Using 1 die, all 6 numbers have an equal chance of occurring.

1. If the scope and sequence lists 6 or fewer lessons, roll the die twice to choose the 2 lessons for the interview.

2. If the scope and sequence lists more than 6 lessons, divide the list into sets each of which includes 6 or fewer. For example, if there are 10 lessons listed, divide the group into 2 sets of 5 and roll the die to choose 1 lesson from each set. If the number 6 comes up, roll the die again.

3. If the group does not divide evenly, for example, 11 lessons are listed, divide the first 10 lessons into 2 sets of 5. Roll the die to determine to which of the 2 sets the 11th lesson should be added. If the die comes up 1, 2, or 3, the lesson goes in the first set. If it comes up 4, 5, or 6, it goes in the second.

4. If more than 12 lessons are listed, for example 15, divided the group into 3 sets of 5 each. Roll the die to determine from which of the 3 sets the 2 lessons will be selected. If a 1 or 4 occurs, a lesson should be selected from the first set. If a 2 or 5 occurs, a lesson should be selected from the second set. If a 3 or 6 occurs, a lesson should be selected from the third set. Repeat to choose the second set. When 2 sets have been chosen, roll the die to select 1 lesson from each set for the interview.

5. If the number of lessons does not divide equally into 3 sets, for example 17, follow the procedure in step 3 to allocate the 16th and 17th lessons to the 3 sets created from the first 15 lessons. Obviously, after the 16th lesson has been assigned to a set, the 17th must be assigned to one of the other 2 sets.

Ask Morgan if you have any questions.

APPENDIX E
CTE Teacher Interview Questions
(revised 3/19/07)

Interviewer reads interview consent script (attached)

The focus of this interview is to help us get a better picture of how you are utilizing explicit math instruction and the Math-in-CTE model in your classes in the academic year following the study.

Overall, what can you tell us about the extent of your use of the Math-in-CTE model in your classroom this year? What are your reasons for this? What has compelled you to use the model in these ways?

If teacher indicates using another model for teaching math, ask: What can you tell us about other approaches you use in making the math explicit in your teaching? How do you use these methods? Examples? How do these approaches/methods affect your use of the Math-in-CTE model?

We want to focus this part of our interview specifically on two of the lessons you reported teaching this year. Will you walk us through the lessons and the 7 elements in each of them?

[Teacher will have been informed in advance which two lessons will be the focus of the interview. Using the lesson plan as a guide, teacher walks through the lessons; interviewer asks clarifying questions and takes notes on attached guide; interviewer collects instructional artifacts—e.g., worksheets, quizzes, handouts, etc.]

You have indicated that you make modifications to the enhanced lessons. How would you characterize those modifications? Can you provide us some examples?

Are you using all 7 elements of the framework, or selecting only parts of lessons to teach? If so, what are you using and why? Explain? Examples?

Can you provide us with some copies of instructional artifacts (problems, worksheets, handouts, etc.) that show how you are using methods, materials, or examples from the study?

What has affected your choices about which of the math-enhanced lessons you teach or don't teach? Explain? Examples?

What kinds of new lessons or instructional materials have you developed in the year following the study? Can provide us with copies of lesson plans and instructional artifacts?

Experimental teachers only:

One of the outcomes teachers identified as making the study successful was the relationships of CTE-math teacher partners and the communities of practice that formed as a result. What can you tell us about sustaining professional interactions with your math-teacher partner following the study? Have you been able to maintain contact or work together in some way? Have you been able to maintain contact with other teams from the study? What is the nature of that interaction? Examples?

> *If teacher indicates working with another math teacher:* How did you select another math teacher to work with? What is the nature of the interaction? Examples?

Control teachers only as indicated by the survey response:

You indicated on the survey that you are in contact with a math teacher. How did you go about finding the math teacher support? Would you describe the kind of math support or help you receive? Examples?

Overall, how did your participation in the Math-in-CTE study affect your overall approach to instruction as a CTE teacher in the year following the study?

Any final comments?

Interviewer concludes:

Do you have any further comments? Do you have any questions?
Thank you once again for taking time to talk with us.
If you have any questions in the future you may contact Dr. Lewis, Dr. Pearson, or Dr. Stone. [provide phone numbers and e-mail addresses if requested]
A report of this study will be submitted to the Office of Vocational and Adult Education (U.S. Department of Education) in December 2006. Once they approve and review the report, it will be available for review on the National Centers' Web site: www.nccte.org

APPENDIX F
Mathematics Teacher Interview Questions
(revised 3/19/07)

Interviewer reads interview consent script (attached)

Overall, what can you tell us about the extent of your use of the Math-in-CTE model in your classroom this year? What are your reasons? What has compelled you to use the model in these ways?

You indicated on the follow-up survey that you have been using methods, materials, and/or examples [refer to survey]. Could you explain or describe this in more detail?

What kinds of occupational (CTE) examples have you been using in your instruction? How extensively do you use these examples and why?

If you utilize the 7 elements in your instruction, how do you do it? Would you walk us through a couple of examples?

What are some other ways you have used the Math-in-CTE methods or materials in your classes?

Can you provide us with some copies of instructional artifacts (problems, worksheets, handouts, etc.) that show how you are using methods, materials, or examples from the study?

One of the outcomes teachers identified as making the study successful was the relationships of CTE-math teacher partners and the communities of practice that formed as a result. What can you tell us about sustaining professional interactions with your CTE-teacher partner following the study? Have you been able to maintain contact or work together in some way? Have you been able to maintain contact with other teams from the study? What is the nature of that interaction? Examples?

> Option: You indicated that you contacted or worked with other CTE teachers. How did you choose the teachers to whom you talked? Did you seek out a certain area of CTE? If so, why? Did you ask them for examples to use in your class? If so, did you use those examples?

Overall, how did your participation in the Math-in-CTE study impact your overall approach to instruction as a math teacher?

Any final comments?

Interviewer concludes:

Do you have any further comments? Do you have any questions?
Thank you once again for taking time to talk with us.

If you have any questions in the future you may contact Dr. Lewis, Dr. Pearson, or Dr. Stone. [provide phone numbers and e-mail addresses if requested]
A report of this study will be submitted to the Office of Vocational and Adult Education (U.S. Department of Education) in December 2006. Once they approve and review the report, it will be available for review on the National Centers' Web site: www.nccte.org

APPENDIX G
Telephone Interview Questions

(for CTE and Math teachers who indicate on the survey that they are not using the Math-in-CTE model)

Before questioning, interviewer will follow telephone consent script (attached)

Experimental and Control CTE Teachers

We are interested in following up on your responses to the Math-in-CTE follow-up survey you returned. Thank you again for your willingness to let us talk with you in more detail about your answers.

Interviewer will ask B1 or B2, as indicated by the individual's survey

B1. You indicated on your survey that you are not currently teaching CTE courses that prepare students for employment. In the future, if you do return to teaching CTE courses, would you choose to include explicit math instruction in your courses?

a. If yes: What are your reasons for doing so? What would you choose to teach and why? Would you follow the Math-in-CTE pedagogy (the 7 elements)? Could you explain/describe more? Could you provide examples? Do you have other comments you would like to share?

b. If no: What are your reasons for choosing not to teach explicit mathematics in your courses? Could you explain/describe more? Could you provide some (other or specific) examples? Do you have other comments you would like to share?

B2. You indicated on your survey that you are teaching CTE courses that prepare students for employment, but that you are not including explicit math instruction because [refer to reasons indicated on survey.] We would like to hear more about [refer to specific reason]. Could you explain/describe more? Could you provide some (other or specific) examples? Do you have other comments you would like to share?

Mathematics Teachers

We are interested in following up on your responses to the Math-in-CTE follow-up survey you returned. Thank you again for your willingness to let us talk with you in more detail about your answers.

B1. You indicated on your survey that you are not currently teaching math courses this year.

In the future, if you do return to teaching math courses, would you choose to include any methods, materials, or occupational examples from the Math-in-CTE study in your courses?

a. If yes: What are your reasons for doing so? What would you choose to teach and why? Would you use any of the Math-in-CTE pedagogy (the 7 elements)? Could you explain/

describe more? Could you provide examples? Do you have other comments you would like to share?

b. If no: What are your reasons for choosing not to use any methods, materials, or examples from the Math-in-CTE study in your courses? Could you explain/describe more? Could you provide some (other or specific) examples? Do you have other comments you would like to share?

B2. You indicated on your survey that you are teaching math courses, but that you are not including anything from the Math-in-CTE study because [refer to reasons indicated on survey.] We would like to hear more about [refer to specific reason]. Could you explain/describe more? Could you provide some (other or specific) examples? Do you have other comments you would like to share?

Interviewer concludes:

Do you have any further comments? Do you have any questions?
Thank you once again for taking time to talk with us.
If you have any questions in the future you may contact Dr. Lewis, Dr. Pearson, or Dr. Stone. [provide phone numbers and e-mail addresses if requested]
A report of this study will be submitted to the Office of Vocational and Adult Education (U.S. Department of Education) in December 2006. Once they approve and review the report, it will be available for review on the National Centers' Web site: www.nccte.org

APPENDIX H
"Other" Responses to Question on Reasons for Not Teaching Explicit Mathematics

Experimental Teachers

- I have taught mathematics related to curriculum, but not explicitly as we did during the study
- Lessons of project do not apply to my CTE class
- The lessons as developed apply to the health occ[upations] core (nat[ional] standards) taught in our first year
- First year instructor for this program - no para pro[fessional] for majority of year. Intend to pull into curriculum next year - unless [state] legislation forces us to do something totally different

Control Teachers

- I do not feel like I received enough training to know how to cover the content. We received a notebook with materials, but had little explanation as to how to incorporate the lessons in class. Basically, I need more information to feel comfortable using explicit instruction in mathematics.
- I plan on using the curriculum when it becomes available in my marketing class when/where appropriate.
- My first attempt to enlist a math partner failed, then I did not keep trying. Once school started, I just did not make the time to get ready. I hope to spend time this summer trying to prepare better for next year. I really do value this concept and this curriculum. My math confidence remains low, so I have got to get help from a math teacher.
- It came down to time for school to begin and I had not gone through the math lessons to prepare myself for incorporation into my curriculum. I fully intend to place them in for next year as I feel the lesson plans are well thought out and will be beneficial to my students.
- Our district uses PLATO for math remediation and instruction at the technical campuses. Students that choose the Pass Assured…...Disk receive "med math: instruction
- I was unable to attend the workshop offered in the summer. I did not receive the CD. The CTE teacher who was in the treatment group dropped from the study. I would like to explicitly teach math in my course.
- Have not attempted to change but would like to. It is difficult to hook up with a math teacher. I look for other ways—internet software, etc.
- English is the included academic component within my class.
- Our school has math classes designed to meet [state] standards. We have teachers available all day to assist students in math. I don't have enough time to teach my automotive curriculum so I send students that have math trouble to our success center for help from a certified math instructor.
- Sudden, unexpected loss of teaching staff has prevented me from including change this year. It is my hope to be able to use math instruction in 2006-07. I have greatly increased student work in math and science but not to the extent needed to be considered explicit.
- I have a co-worker who teaches math with the occupational content.
- Most of my students tested are primarily in the class to develop welding skills, etc.