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Introduction to the *Leader's Guide*

This book, *A Leader's Guide to Mathematics Curriculum Topic Study*, is the natural companion to the parent book, *Mathematics Curriculum Topic Study: Bridging the Gap Between Standards and Practice* (Keeley & Rose, 2006). The curriculum topic study (CTS) parent book provides an introduction to the process of CTS; the resources used to engage in CTS; various ways to use CTS to support content knowledge, curriculum, instruction, and assessment; and the 92 CTS study guides that contain the prevetted readings used in CTS. It has become an essential resource used by mathematics educators to improve their practice. This Leader's Guide offers practical suggestions for using the parent book, including tools, designs, and additional resources for incorporating CTS into the work mathematics leaders do to support teacher learning. This *Leader's Guide* was developed to assist teacher educators and leaders, such as preservice faculty, mathematicians who provide content support to teachers, mathematics specialists, instructional coaches, teacher leaders, and professional development providers, in developing the professional knowledge base mathematics teachers need to be effective in the classroom. It provides tested strategies for introducing the CTS process that builds preservice and inservice teachers' knowledge of the research on learning mathematics and the national standards, focal points, and benchmarks that are the bedrock for ensuring quality teaching and mathematical literacy for all. Furthermore, it supports forms of teacher learning in collegial groups and professional learning communities (PLCs) that are guided by a common knowledge base as teachers work together to plan lessons, examine student work, develop assessments, select curriculum, and go about the daily business of educating our nation's youth.

ADVICE FOR USING THIS *LEADER'S GUIDE*

Users of this *Leader's Guide* may wonder how they should begin using this book. You may be asking, *Where do I start? In what order do I use it*? *What else do I need to effectively use this book?* There is no single answer to these questions. It depends on your familiarity with

CTS and your purpose for using it. We do encourage all leaders who use this *Leader's Guide* to have a copy of the parent book as well as the resources listed in Table 1.1. Often, throughout this guide, we will be referring you to sections and pages in the parent book, and it will help you to have it to consult.

Table 1.1 Essential Resources for Leaders of CTS

CTS Resources	*Available Through*
Mathematics Curriculum Topic Study (Keeley & Rose, 2006)	Corwin (http://www.corwin.com)
Beyond Numeracy (Paulos, 1992)	Major bookstores and online booksellers
Science for All Americans (AAAS, 1989)	Oxford University Press (http://www.us.oup.com/us/) Major online booksellers Available to read online at http://www.project2061.org/publications/sfaa/default.htm
Benchmarks Online (AAAS, 1993–2009)	Oxford University Press (http://www.us.oup.com/us/) Major online booksellers Available to read online at (includes new and revised benchmarks) (http://www.project2061.org/publications/bsl/default.htm)
Principles and Standards for School Mathematics (NCTM, 2000)	Major online booksellers NCTM (http://nctm.org) Available to read online for NCTM members
Research Companion to Principles and Standards for School Mathematics (NCTM, 2003)	Major online booksellers NCTM (http://nctm.org)
Atlas of Science Literacy Volumes 1 and 2 (AAAS, 2001–2007)	Major online booksellers NSTA Press (http://www.nsta.org/store/) All maps are available online at http://strandmaps.nsdl.org
Common Core State Standards for Mathematics (NGA Center & CCSSO, 2010)	Common Core State Standards Initiative (CCSSI) (http://corestandards.org)

Note: Although not in the original CTS guides, the Common Core State Standards can be added by the facilitator to Section III in the 2006 CTS guides.

Before you begin using this *Leader's Guide*, it is important to become familiar with the parent book, CTS resources, and experience a CTS. If you have never conducted a CTS on your own, pull out your parent book. From it, select one of the 92 CTS topics of interest to you, and follow the process described in Chapter 3 of that book, "Engaging in Curriculum Topic Study." Wear two hats as you conduct your own CTS: (1) As a learner, reflect on what knowledge you gained as you did the CTS, and (2) as a leader of professional development, consider what you need to do to facilitate this type of learning with others. Compare what learners do with what a facilitator would do throughout the process on pages 49–50 of the parent book to get a sense of what the teachers you work with will be doing and what you will be doing as a CTS facilitator.

CTS is a versatile professional development tool with multiple uses and purposes. We do not prescribe a linear, step-by-step process for using CTS in your work. Where you start, the sequence you use, the designs you select, the tools you use, and the supplementary resources you include will be as varied as the diverse types of leaders who are using CTS. Each of the chapters in this book will begin by describing what is in the chapter and how leaders might use it. Although step-by-step scripts are provided for many of the CTS designs, we encourage you to adapt the materials to the needs of your audience and to your own facilitation style.

Before implementing the designs, tools, and suggestions in this book, it is important to have a deep understanding of how CTS enhances professional development, the different purposes it achieves for teacher learning, the variety of ways to embed it into your own teacher learning contexts, and the language used throughout CTS and this book. This groundwork should be done first if you plan to regularly use CTS in your work. This chapter addresses the question "Why Use CTS?" It will provide you with the rationale for using CTS and lay the groundwork for you to use the material provided in the subsequent chapters.

UNDERLYING BELIEFS

As suggested in the Preface to this book, the education field has undergone a tremendous transformation in beliefs about what constitutes effective learning for both children and adults and what it takes to be a quality teacher. There is a growing recognition of the complexity of teaching and the vast array of knowledge a teacher must possess to meet the needs of a wide range of students. We know more now than ever before about procedural and conceptual learning in mathematics, and we are learning more all the time. As the education field, and in fact our entire culture, becomes one that is knowledge-using and knowledge-producing, teachers are increasingly using and contributing to the education knowledge base. These developments have provoked two strong underlying beliefs that undergird the CTS work. These are as follows:

1. Teachers, like other professionals, must possess and continue to build their own *specialized knowledge base*. For teachers, this consists of content knowledge and knowledge about teaching in a specific content area, including an understanding of how children of a certain age learn, called pedagogical content knowledge (PCK). Teachers continue throughout their careers to develop and actively use their specialized knowledge base to guide their educational practice.

2. Teachers, like other professionals, should be engaged in *collegial professional learning communities* that are guided by strategic and enduring goals and focused on enhanced learning and ongoing improvement. These communities should be knowledge-using and knowledge-producing and be guided by two very basic ideas: Use the knowledge generated from standards and research to provide evidence and justification for your ideas, and learn from the expertise of others shared through peer-reviewed literature, conference presentations, and the wisdom of thoughtful practitioners.

Each of these beliefs has changed how we think about the content and purpose for professional development for mathematics teachers and has had a major impact on how teachers are engaged in professional learning. CTS supports teachers to build their specialized teaching knowledge and participate in productive collegial communities focused squarely on putting research and standards to work in the classroom. Throughout this book, you will see examples of how teachers can use CTS to enhance their content and pedagogical knowledge in collegial, collaborative learning environments. You will see how teachers use knowledge gained from CTS as well as contribute new knowledge about teaching and learning in their own unique contexts through professional development strategies described in Chapter 7 such as study groups (or PLCs), case discussions, and video demonstration lessons.

THE NEED FOR A COMMON PROFESSIONAL KNOWLEDGE BASE

Over the last few decades, the education field has learned more about what it takes to develop qualified teachers in mathematics and the knowledge, skills, and mind-sets that support teaching and learning in this discipline. New ideas have been shaped and influenced by the growing research base that provides educators with insights into how students develop their understanding of specific ideas in mathematics and how mathematical misunderstandings may impede learning if they are not surfaced and taken into account when designing instruction. There is greater awareness and use of recommended practices such as establishing a clear and coherent curriculum, focusing on an explicit set of standards-based learning goals, using instructional strategies that support and deepen student learning of key mathematical ideas, and embedding standards- and research-based assessments throughout instruction that inform teaching and provide information on the extent to which students are achieving a learning goal. Increasingly educators are asked by administrators and others to justify requests for new programs or practices with objective evidence of success. Stakeholders want to know what works and are looking to professional educators to identify and explain effective practices that can lead to increased student achievement.

These developments have given way to new ideas about teacher professional development. We know that mathematics teaching involves much more than procedures, hands-on activities, and use of manipulatives, teaching tips, and general pedagogical techniques. Professional teachers must possess both content and PCK, the specialized knowledge of content and how children learn it. This knowledge enables teachers to focus on important learning goals and provide developmentally appropriate and coherent instruction and assessments. Quality professional development programs are increasingly focused on enhancing teachers' understanding of mathematical content and how to teach it. Teachers are learning to review and revise their instructional materials and methods to better reflect alignment with standards and research on learning and are taking collective responsibility for knowing not only their content, but also how children think about mathematical ideas and what types of experiences, examples, and representations can best support learning.

One of the characteristics of professional teachers is their belief in the importance of acquiring their own professional libraries or having access to professional resources to regularly inform their teaching and expand their knowledge base. Knowledge of effective mathematics teaching does not end after graduation from a teacher preparation program or graduate program. Teachers are constantly seeking the wisdom and knowledge shared by researchers and expert practitioners that help them grow and develop as professional mathematics teachers. There is a plethora of professional literature to support mathematics teacher learning. However, the vast collection of literature can be narrowed down to six major publications that best support standards- and research-based teaching and learning across all the areas of mathematics, grade levels, and teacher expertise. These are the common and collective resources identified by the CTS project that can be used with the 92 mathematics curriculum topics identified in the parent CTS book. These professional resources should be in the library of every mathematics teacher and teacher educator, whether they are part of their own collection or shared within a school or organization. These resources are listed in Table 1.1 and provide a common knowledge base that all teachers can refer to and use. The fact that these books were authored by highly respected scientists, mathematicians, researchers, and mathematics educators and some, such as the national standards documents, went through an extensive national review process that involved consensus from the mathematics education community at large makes them credible and relevant to all mathematics educators striving to develop shared understandings of content, teaching, and learning. Having access to these books is like having an expert at your fingertips 24/7! In addition, we have added the link to the *Common Core State Standards for Mathematics* to Table 1.1 (NGA Center & CCSSO, 2010). When the CTS parent book was published in 2006, these standards were not available. Hence, they are not included in the CTS study guides. However, facilitators can choose to add these to the guides when working with a group to conduct a topic study. More information about including the *Common Core State Standards for Mathematics* is included in Chapters 2, 4, and 5.

CTS MAKES THE KNOWLEDGE BASE ACCESSIBLE

As described in the Preface, many teachers, and even some teacher educators, have never used or even heard of some of these resources, even though most have been out for more than a decade. As the use of CTS grows, these resources are becoming better known and more frequently used in the mathematics education community. As a facilitator, one of the changes you will see firsthand as you use CTS with teachers is the renewed emphasis and embrace of the national standards and research literature, even though states have their own standards.

Prior to CTS, getting to know and use national standards and research on learning posed several difficulties. The focus on state standards shifted teachers' attention away from the more detailed source documents on which many of these state standards were based. As we discussed in the Preface, we found that many teachers had no knowledge of publications like *Science for All Americans* (American Association for the Advancement of Science [AAAS], 1989) and the *Research Companion to Principles and Standards for School Mathematics* (National Council for Teachers of Mathematics [NCTM], 2003). Some had heard of the NCTM *Principles and Standards for School Mathematics* (NCTM, 2000) and the *Benchmarks for Science Literacy* (AAAS, 1993, 2009) but had never opened a copy or even realized that these publications contained much more than a list of what students were expected to know and be able to do in mathematics. They didn't know enough about the publications to know how useful they could be in informing teaching and learning. Furthermore, we now have the *Common Core State Standards for Mathematics* (NGA Center & CCSSO, 2010), which was not available when CTS was first published in 2006.

For others, the standards and research publications were available, but a process for using them was missing. Some teachers found navigating through the publications to be difficult and unwieldy. They consulted the standards documents, sifting through the hundreds of pages of text to find what was relevant to their curriculum, their students, or their teaching and often struggled and became frustrated because the answers they were seeking were so hard to find. They did not know how to use the essays or why the learning goals were written a certain way. They struggled with figuring out how to sequence and connect standards coherently. Many never realized there was a chapter in the back of the *Benchmarks for Science Literacy* that contained summaries of mathematics research connected to the chapters describing what all students should know. They didn't realize how *Science for All Americans* is the seminal, enduring document that lays out a vision for the standards documents, including an eloquent description of the mathematics all adults should know and be able to use to be considered a mathematically literate person.

For those who persevered, their efforts paid off in gaining clarity about the standards and how they relate to teaching and learning, but it took a substantial time commitment and their searches often ended when they identified learning goals for their particular grade span. As advocated by Project 2061 of the AAAS, all teachers need a broad and deep understanding of all science, mathematics, and technology topics, what we commonly refer to today as the STEM disciplines. They should know what every 12th-grade graduate is expected to know and the level of schooling in which students are expected to learn certain ideas in mathematics. They should understand not only the learning goals at each grade span, but also the research suggesting what is difficult or easy for students to learn, the contexts and strategies that support learning, the connections within and across mathematics topics, and how a coherent understanding grows over the K–12 sequence. But how do teachers develop this knowledge? Where can they find the tools and the time? CTS provides the means and the organized process to help education professionals use these professional publications efficiently and effectively. Most important, it has gotten the books off the shelf and into the hands of teachers so they could use them. The CTS project identified 92 relevant curriculum topics and prescreened and identified all the readings from the resource books that would contribute to a teacher's understanding of the professional knowledge described above. These readings are combined in a study guide and facilitated through a process that engages teachers in a deep and thoughtful study of teaching and learning connected to a curricular topic they teach.

In our experience introducing CTS to teachers, familiarity with and access to the CTS resources tended to be more on the side of the standards documents than the research. Teachers seemed to have less familiarity with and access to the research base on student learning. We know from cognitive research that students often have strong preconceptions and develop their own rules and generalizations about mathematical ideas that may support or interfere with their learning (Bransford, Brown, & Cocking, 2000; Donovan & Bransford, 2005). Being aware of student difficulties and the sources of those difficulties, and designing instruction to diminish them, are important steps in achieving the goal of mathematical understanding (Yetkin, 2003). For example, some students hold the common misconceptions that multiplication makes things bigger or that the larger the denominator is, the larger the fraction (Rose, Arline, & Minton, 2007). Each of these ideas is encompassed either explicitly or implicitly in the state standards teachers and students are held accountable for achieving. By using CTS, teachers can identify key ideas in their standards and then refer to research summaries to know what may make the learning difficult or comprehensible to students. They can use this information to plan instruction at their own grade level or comprehensively across grade levels. They now have a way to access and link the research to K–12 student learning goals.

BUILDING PROFESSIONAL COMMUNITY

The other underlying belief that is changing teacher professional development for the better is the growing commitment to building PLCs among teachers. After more than a century of schools that operated like multiple one-room schoolhouses under one roof, the idea of a PLC and teamwork in schools is finally taking hold. In the recent past, teachers across the hall or just next door may have been struggling with the same questions and problems with no reason or way to collaborate to find solutions. Increasingly, teaching is being deprivatized by the growing number of PLCs in schools that examine practice and results on a regular basis and pursue solutions to the problem of poor student performance. However, like other innovations, building a PLC does not happen by magic, and there are many pitfalls that must be addressed. In our work, we have focused on putting the "professional" into the PLC. We have asked, "What are the tools teachers need to make sure they reflect the knowledge of the profession in their learning communities?" Our conclusions are that PLCs must be research-based and standards-driven to be "professional." Historically, isolation among teachers led to very little sharing of what works among educators. Recent technologies and new organizational structures are helping to change that. Yet teachers' days are still highly structured and scheduled, and they need efficient and effective ways to work together and put their professional knowledge to work. Through CTS, once teachers learn the process, they can quickly and efficiently explore the readings on any given mathematics topic to address questions of practice and inform deliberations and decisions for their own teaching and to share with others in their PLCs. Whether they are involved in a formal PLC that meets to examine results and pinpoint areas for improved student learning or a grade-level team monitoring how new curriculum materials are working, the CTS process will support and enhance these collegial groups of teachers to use the research and the standards to inform their work. Through the use of CTS we have seen the conversations in these groups shift from the autobiographical stories that emanate from "What are you doing in your classroom?" to scholarly discussions that pertain to all teachers, such as, "What do the national standards and research say, and how might we apply that in our classrooms to support implementation of our state standards?" Examinations of curricular or instructional strategies are enriched because teachers base their analyses on whether the materials and strategies reflect important and challenging key ideas and research on how children learn as opposed to focusing only on their own opinions or biases, or on the materials' style, layout, or reading level.

As schools and school districts support new organizational arrangements that reduce hierarchy and promote collaboration, CTS can help at every juncture. As Ann Jolly, a former middle school teacher and an Alabama Teacher of the Year, reports, "PLC's involve teams of teachers in working together to study, learn, and support one another as they make changes in classroom practice. This process is collaborative rather than isolated. Ongoing learning and support continue throughout the school year. This professional development occurs at the school site and focuses on needs of the specific students in that school. Teachers work as interdependent colleagues, and a culture of collaboration and collective responsibility takes root. When teachers work together in PLCs to implement new teaching practices, over 90% of teachers do so successfully. Teamwork and collaboration work!" (Jolly, 2007, para. 8).

PLCs are usually organized as collaborative teacher groups focused on learning and achieving desired results. Eaker, DuFour, and Burnette (2002) suggest that PLCs systematically address four key learning questions:

1. What do we want students to learn?
2. How will we know if they have learned it?
3. What does student learning data reveal?
4. What are we going to do if students are not learning?

Too often, however, these collaborative groups lack a systematic focus on disciplinary content and drawing upon the knowledge base on learning mathematics to adequately address these questions. Table 1.2 shows how the CTS process and specific sections of the study guides in the CTS parent book can be used to address these questions. Beginning with the first question, CTS can guide the school community to ensure that the mathematics learning objectives the group chooses are enduring and that important ideas reflected in the national standards are clarified so that key ideas and procedures are clear and explicit and supported developmentally and conceptually by research. In addressing the second and third questions, CTS can also help the community use assessments that probe for understanding by using the CTS process to develop and use ongoing formative assessments that link key ideas in the standards to common misconceptions and misunderstandings, and reveal whether students have similar ideas to those identified in the research. Teachers examine students' results on assessments that reveal their thinking to decide what is needed next. The fourth question may be answered by examining the K–12 articulation of learning goals to determine whether gaps exist that may pose barriers to learning, analyzing curriculum materials to see the extent to which they promote learning of the key ideas, identifying instructional contexts that have proven effective in supporting learning, or even by examining teachers' own content knowledge to determine whether they are making the right connections. Table 1.2 shows how the different sections of the CTS process can support key questions for PLCs. (For a refresher on the six different sections of a CTS guide and the resources that are used with the sections, turn to page 21 in the parent CTS book or refer to Handout A1.5 in the Chapter 4 folder of the CD-ROM for this guide.)

Table 1.2 Key Questions for Professional Learning Communities and How CTS Can Help

Key Question	*PLC Use of CTS*
What do we want students to learn about a particular mathematics topic?	• CTS Sections III, V, and VI: Identify the learning goals that align with the topic; unpack the concepts, ideas, or skills within the learning goals for the topic. • CTS Section V: Identify the connections among related concepts; examine how key ideas build. • CTS Section I: Examine the culmination of K–12 mathematics literacy ideas for enduring understanding and use into adulthood.
How will we know if they have learned it?	• CTS Section IV: Identify common difficulties and misconceptions that may be revealed through instruction and assessment. • CTS Sections III, IV, and VI: Develop and use formative assessments and culminating performance tasks to check for understanding before, throughout, and at the end of instruction.

Key Question	*PLC Use of CTS*
What does the student learning data reveal?	• CTS Section III: Identify the extent to which students' ideas match the key ideas in the standards. • CTS Sections II and IV: Identify common difficulties, errors, and misconceptions that impede learning.
What are we going to do if they do not learn?	• CTS Section II: Examine instructional contexts and suggestions to determine if curricular or instructional changes are needed. • CTS Sections II and IV: Examine ways to address student difficulties and misconceptions. • CTS Section V: Examine the K–12 articulation of learning goals to see if there are gaps that need to be filled; look for ways to make stronger connections among a coherent set of learning goals.

OBSERVATIONS AND VOICES FROM THE FIELD

The results of using CTS have been impressive. As one teacher leader who used CTS said, "The process is an essential tool to bridge the gap between research and standards-based practice in teaching mathematics." A mentor teacher reported that CTS is especially useful in situations where mentors work with novice teachers and that the novice teachers are not the only beneficiaries. She described how mentors also show tremendous growth in skills and understandings when they use CTS as part of an induction program for beginning teachers.

Many users have commented on the ease and versatility of the CTS materials. For example, one participant said, "The [materials] allowed for a directed view of where to look in the CTS guides for the information we needed." Another pointed out that "developing our own [assessment] probes helped to give insight into what it takes to develop a good formative assessment item that can uncover the misconceptions our students have."

One of the greatest results we have seen comes from the teacher "ah-ha" moments. For example, one leader reported this insight: "Our participants left the workshop with an awareness of how the CTS process can enrich their current teaching practices. Several of the teachers commented that they had never used any of these source books prior to their CTS introduction. From now on they will become an integral resource for their district planning."

As another teacher commented: "I will use this to preview the most important mathematics to teach."

Teachers have also pointed out that the most valuable aspect of CTS for them is the review and discussion of misconceptions and misunderstandings described in the research on learning. As one teacher said, "It's a 'wake-up call' to all teachers that instruction strategies/techniques that address misconceptions and common errors are keys to learning."

One professional developer we worked with summed up the value of CTS this way: "CTS is a systematic procedure anyone can use; it provides synthesized information on specific topics and thus saves time in looking for answers; it helps users work from a common understanding of a particular topic to answer a specific question; and it helps users develop the habits of good research strategies."

After experiencing CTS, leaders of professional development for mathematics teachers immediately saw the significance of using CTS to enrich and invigorate teacher learning programs. Many professional developers in mathematics are not experts in every mathematics topic area or grade level. Some with excellent backgrounds in one grade level, such as high school mathematics, may be responsible for designing teacher learning programs in the middle or elementary grades. They need an easily accessible process for gaining a clear vision of the important mathematics across the K–12 system and how to make the mathematics content accessible to all students. CTS provides such a tool.

PROFESSIONAL DEVELOPMENT DESIGNS ARE ENHANCED THROUGH CTS

Professional development for mathematics teachers comes in a variety of forms and structures ranging from half-day workshops to weeklong institutes, to ongoing collaborative structures like PLCs. Regardless of the type or length of the professional development experience, CTS increases the focus on the content by connecting it to the key ideas in the standards and the research on learning. This increased focus ultimately translates into improved student achievement. For example, leaders who are instructional coaches should routinely do a CTS on the topics they are addressing in their coaching. Sometimes these leaders use this information for their own planning, but more often they incorporate it into the work they do with teachers, such as collaboratively planning and providing feedback on a lesson. In Chapter 7, you will find examples of professional development where the leader uses CTS with teachers in the context of particular professional development strategies. CTS is so valuable for leaders that we believe that no professional development leader should plan content-focused workshops, sessions on looking at student work, or any mathematics professional development without first doing a CTS on the topics they will address in their professional development session. This book contains the tools and resources to support them not only to do that, but also to build in rich CTS experiences for the teachers they work with to improve mathematics education.

CTS is a versatile resource designed to address multiple needs, audiences, and contexts. Likewise, this *Leader's Guide* addresses the multifaceted nature of professional learning and the different types of leaders who may design and support teacher learning using CTS. To give you a sense of the versatility of CTS when it is used within different contexts, the following are just a few examples of the various ways leaders use CTS. They also show how the CTS underlying beliefs of building specialized knowledge of mathematics teaching and learning as well as supporting collaborative group learning are manifested through these examples.

CTS USE BY COLLABORATIVE SCHOOL TEAMS

Improving student learning is at the heart of what teachers do. When teachers encounter students having learning difficulties, one reaction has been to simply reteach the content in the same or a slightly different way. Another approach is to gather data to find out what the students are having difficulty understanding and if other teachers at the same grade level are experiencing similar results. In this second approach, CTS resources help to pinpoint how to make the content more accessible to students. Improving opportunities for students to learn mathematics content by first examining teachers' own content knowledge, analyzing key ideas they want their students to learn, identifying instructional contexts that can enhance learning, becoming aware of the research on students' ideas in mathematics and how they impact learning, and understanding how learning progresses from one idea to the next in a coherent sequence of ideas improves both the quality of teaching and subsequently the depth and endurance of learning.

For example, a middle school team might observe that their students seem to perform poorly on assessment items on the state test that involve measurement. The teachers wonder what they can do to improve students' abilities to use different measurement systems. Although their students have had opportunities to use measurement skills in both science and mathematics, the students always score low on the measurement section, especially when it involves metric systems of measurement. The team decides to use the Linear Measurement Module (see Chapter 5) to investigate the topic. During the CTS, they clarify the specific measurement concepts and skills students are expected to know and be able to do. Furthermore, the team was interested in delving deeper into the research, which pointed out that students often know how to take measurements but do not know when to measure or what to measure.

Overall, the CTS helped the team understand why their instruction was not working for their students and what they needed to do so that their students could achieve the targeted learning goals. As a group, they revisited their curriculum and instructional materials and strengthened the measurement components. The conversation shifted in the team from an activity focus to a learning focus, guided by the common knowledge base they now had as a team as a result of doing the CTS together.

CTS USE IN PRESERVICE TEACHER EDUCATION

Preservice teachers in mathematics education courses benefit tremendously from using CTS at the beginning of their careers. Not only does it establish a habit of practice that will be useful to them throughout all the stages of their career, but it also helps them link their preservice experience to the current emphasis in many schools on standards and research-informed instruction. For example, most preservice teachers are asked to design at least one lesson as part of their methods course requirements. CTS provides the information they need up front to ensure their lesson appropriately addresses important key ideas in mathematics and anticipates the commonly held ideas students might bring to their learning. CTS creates the awareness needed for preservice teachers to design effective lessons that address standards and are informed by research on learning. In the process, many preservice teachers, particularly those who have limited mathematics backgrounds, find they are gaining new knowledge about content, teaching, and learning and realize areas where they would like to continue their mathematics content learning. It also brings a deep appreciation early on in their careers of the need to have and use a professional library of resources that will help them teach in a system that increasingly focuses on accountability to standards and instructional decisions based on research.

CTS ENHANCES MATHEMATICS EDUCATION LEADERSHIP

CTS has many benefits for people in mathematics education leadership roles such as school and district administrators, teacher leaders, and coaches. In our CTS work, we encourage all leaders working in these roles to use CTS to increase their familiarity with mathematics standards and learning research and how they are used to inform curriculum, instruction, and assessment. Depending on one's role, these leaders may need more in-depth understanding of the key ideas in the learning goals and the commonly held ideas noted in the research on learning in any particular grade spans.

District Mathematics Coordinators

For example, district mathematics coordinators are often responsible for curriculum adoption and development committees, overseeing and supporting coaches, arranging and approving professional development in mathematics, making classroom observations, requesting resources and manipulative materials and related tasks that require them to have a very broad and deep understanding of K–12 mathematics. Very often they may be specialists in one particular area of mathematics education (e.g., high school mathematics) but may not have firsthand knowledge about what learning strategies are effective for teaching basic geometry concepts in Grade 4 or the common difficulties students have when learning about fractions. They can benefit from basic numeracy topics engaging in full curriculum topic studies on topics that are the focus of new curriculum to inform the selection of professional development programs and to make a research-based case for using certain instructional strategies or materials. Every mathematics coordinator should own a copy of the CTS book and the accompanying resource books listed in Table 1.1. They should actively share these books with the people they work with to encourage others to use CTS to inform teaching actions and decisions.

District Mathematics and Science Coordinators

Some smaller districts combine coordination responsibilities for both science and mathematics. These Mathematics and Science Coordinators benefit from using both the mathematics CTS book and the parallel science version—*Science Curriculum Topic Study: Bridging the Gap Between Standards and Practice* (Keeley, 2005). Figure 1.5 in the CTS parent book shows how several of the resources used in mathematics CTS are also used in science CTS. In addition, there are several topics that overlap such as the Graphs and Graphing or the Mathematical Modeling CTS guides used in science and the Graphic Representation or the Modeling CTS guides used in mathematics. Engaging teachers in a study of similar cross-disciplinary topics helps coordinators facilitate the integration of common topics across the mathematics and science curriculum as well as foster a STEM approach to teaching and learning.

Table 1.3 Common CTS Resources in Science and Mathematics

CTS Resources	*Comments*
Mathematics Curriculum Topic Study (Keeley & Rose, 2006) and *Science Curriculum Topic Study* (Keeley, 2005)	These parent books are designed to parallel each other.
Science for All Americans (AAAS, 1989)	Describes the level of literacy all adults should have in science and mathematics after completing a K–12 education.

CTS Resources	*Comments*
Benchmarks for Science Literacy (AAAS, 1993) or *Benchmarks Online* (AAAS, 2009—includes new and revised benchmarks)	Describes explicit learning goals, descriptions of effective teaching and instructional contexts, and summaries of the research on learning.
Atlas of Science Literacy, Volumes 1 and 2 (AAAS, 2001–2007)	Visually illustrates a progression of understanding from K–12 and shows connections within a topic and across topics.

Principals

Programs that train principals can also use CTS to help prospective school administrators develop an understanding of what they should look for when teachers are teaching certain mathematics topics. For example, one principal said he was wondering why a teacher he observed had been asking her students questions about content that was not directly addressed in the lesson being taught, and he noted it in the evaluation as a concern. After the lesson, he asked the teacher about it. She shared with him that she had a hunch that students were missing some of the prior knowledge needed to understand the topic of probability that she was teaching. She pulled out the map on Probability from the *Atlas of Science Literacy* (AAAS, 2000) and showed the principal the concepts and specific ideas that students are expected to develop at each grade level and pointed out the areas she was probing students about to see if they had the prior knowledge that served as a precursor to the ideas she was trying to develop in her lesson. She showed him the CTS study guide that indicated which *Atlas* map to use to examine the topic she was teaching. The principal developed a greater appreciation for what this teacher was doing to assess prior knowledge and quickly saw how using CTS himself would inform his classroom observations. Although principals do not have to know every bit of information on the 92 mathematics topics included in Mathematics CTS, it is important for them to experience CTS enough so that they know its purpose and can suggest teachers use it as they are planning lessons, developing assessments, and reviewing the essential content students should learn. In addition, administrators should encourage teachers to use CTS to justify decisions they make regarding teaching and learning.

Teacher Leaders and Instructional Coaches

Teacher leaders and coaches are other key leadership groups that can strengthen and enhance their leadership capacity through CTS. Teacher leaders and coaches are often chosen because they stand out among peers and are successful with their own students. When they begin to work with a variety of teachers they are challenged to know the goals for mathematics learning across many grade levels and they must be a resource for teachers who may be teaching topics at a grade level the coach or teacher leader is not familiar with firsthand. CTS helps in both areas. When leaders use CTS themselves, they can quickly and efficiently review the standards and research to inform what they do to support their teachers. They can also introduce CTS tools to the teachers they work with so they have access to the information they need anytime. It is like having a virtual expert on call anytime the coach, mentor, or teacher leader is not readily available to provide assistance.

The Language of CTS

Like any new tool or resource, CTS comes with its own language, specialized terminology, and operational definitions. For the purpose of clarity, Table 1.4 lists words and terms frequently used throughout this *Leader's Guide*. Descriptions of how this terminology is used in the context of CTS as well as operational definitions for words that may have different meanings in other contexts is provided for leaders to ensure consistency when using CTS in your professional development contexts. In addition, this chart is provided as Handout 1.1 in the Chapter 1 folder on the CD-ROM if you choose to share it with teachers, adapt it, or add your own additional terminology that you use in your CTS professional development.

Table 1.4 CTS Specialized Terminology

CTS Terms	*Clarification*
Common misunderstandings	A pervasive notion about a mathematics concept that has been studied in groups of students with results published in the research literature and is very likely to be held by students outside of the study.
Common Core State Standards	A robust set of standards developed by the Common Core State Standards Initiative and accepted by 40+ states that describe core ideas in mathematics crucial for success in college and careers.
Concept	A mental construct used to conceptualize a mathematical idea (e.g., similarity, mean, ratio, linearity, etc.).
Conceptual knowledge	Knowledge of mathematical ideas and their interconnections that enables one to understand mathematics and solve problems.
Content knowledge	Knowledge of disciplinary subject matter (e.g., geometric ideas, measures of central tendency, proportionality, functionality, etc.).
CTS	An acronym that stands for curriculum topic study.
Grain size	How broad or specific a topic is (e.g., Geometric Shapes is a large grain size topic whereas Triangles is a smaller grain size topic).
Integrated topic	Cross-cutting topics in mathematics that help provide coherence to the mathematics curriculum and are threaded through multiple content areas (e.g., proportionality cuts across measurement, geometry, number and operation, algebra, and probability).
Key idea	An important idea unpacked from a learning goal. Sometimes there are several key ideas embedded in one learning goal.
Leader's Guide	A shorthand way of referring to this book, *A Leader's Guide to Mathematics Curriculum Topic Study.*
Learning goal	A teaching and learning target that specifically describes what students should know or be able to do. In the NCTM *Principles and Standards*, these are referred to as "Expectations."

CTS Terms	*Clarification*
Misconception	A catch-all term for ideas students have that are not entirely mathematically correct (e.g., partial understandings, overgeneralizations, misunderstandings, common errors).
National standards	Both the *Benchmarks for Science Literacy* and the *Principles and Standards for School Mathematics.*
Overgeneralizations	A type of common misunderstanding developed when an algorithm, rule, or shortcut is extended to another context in an inappropriate way.
Parent book	A shorthand way of referring to the resource *Mathematics Curriculum Topic Study: Bridging the Gap Between Standards and Practice* (Keeley & Rose, 2006).
PCK	An acronym that stands for pedagogical content knowledge. This is the specialized knowledge about mathematics teaching and learning that teachers need to understand in order to make content accessible to students.
Preconception	An idea formed, often early on, before students formally encounter the content. Preconceptions can form outside of school or during previous curricular contexts.
Procedural knowledge	Knowing algorithms, representations, and mathematical facts and when to use them to solve problems.
Procedure	A standard process for solving a class of mathematical problems.
Professional learning community	A group of team members who regularly collaborate toward continued improvement in meeting student learning needs through a shared vision and focus on curriculum, instruction, and assessment.
Research	Although there are many kinds of research in education, in CTS this refers specifically to cognitive research (research on learning).
Science literacy	The understandings and ways of thinking that are essential for all citizens in a world shaped by science and technology. Included in science literacy are understandings related to the nature of mathematics, mathematical ideas, and mathematical skills (AAAS, 1989).
Sophistication	Refers to the complexity of an idea at a given grade level. For example, the 3-5 symbolic representation idea "mathematical ideas can be represented symbolically" is at a lower level of sophistication than the 6-8 idea relating symbolical equations to describe the relationship between two quantities.
Standards	Common goals established nationally, statewide, or locally that are widely accepted by the mathematics education community and provide a focus for teaching and learning.

(Continued)

Table 1.4 (Continued)

CTS Terms	*Clarification*
Study guide	Refers to one of the 92 CTS study guides.
Teacher educator	Anyone who facilitates teacher learning such as preservice faculty, mathematicians working with teachers, staff developers, coaches, and so on.
Topic	A conceptual organizer or category for related learning goals that can be taught in a variety of contexts (e.g., Geometric Shapes is a CTS topic, but Tangrams is a context in which manipulatives are used to teach about geometric shapes).
Topic study	A shorthand way of referring to a curriculum topic study.

Chapters 1 and 2 in the parent book, *Mathematics Curriculum Topic Study* (Keeley & Rose, 2006), introduce the user to CTS and the tools and collective resources used with the process. In Chapter 2 of this *Leader's Guide*, we will expand upon these two chapters by describing what leaders need to know in order to introduce CTS effectively in their work with mathematics educators.