



Mathematical Discourse

Let the **Kids Talk!**

Critique

Justify

Question

Barbara Blanke

Foreword by **Steve Leinwand**

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Shell Education

A Division of Teacher Created Materials
5301 Oceanus Drive
Huntington Beach, CA 92649-1030
<http://www.tcmpub.com/shell-education>

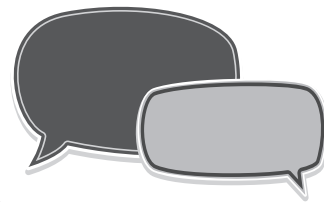
ISBN 978-1-4258-1768-8

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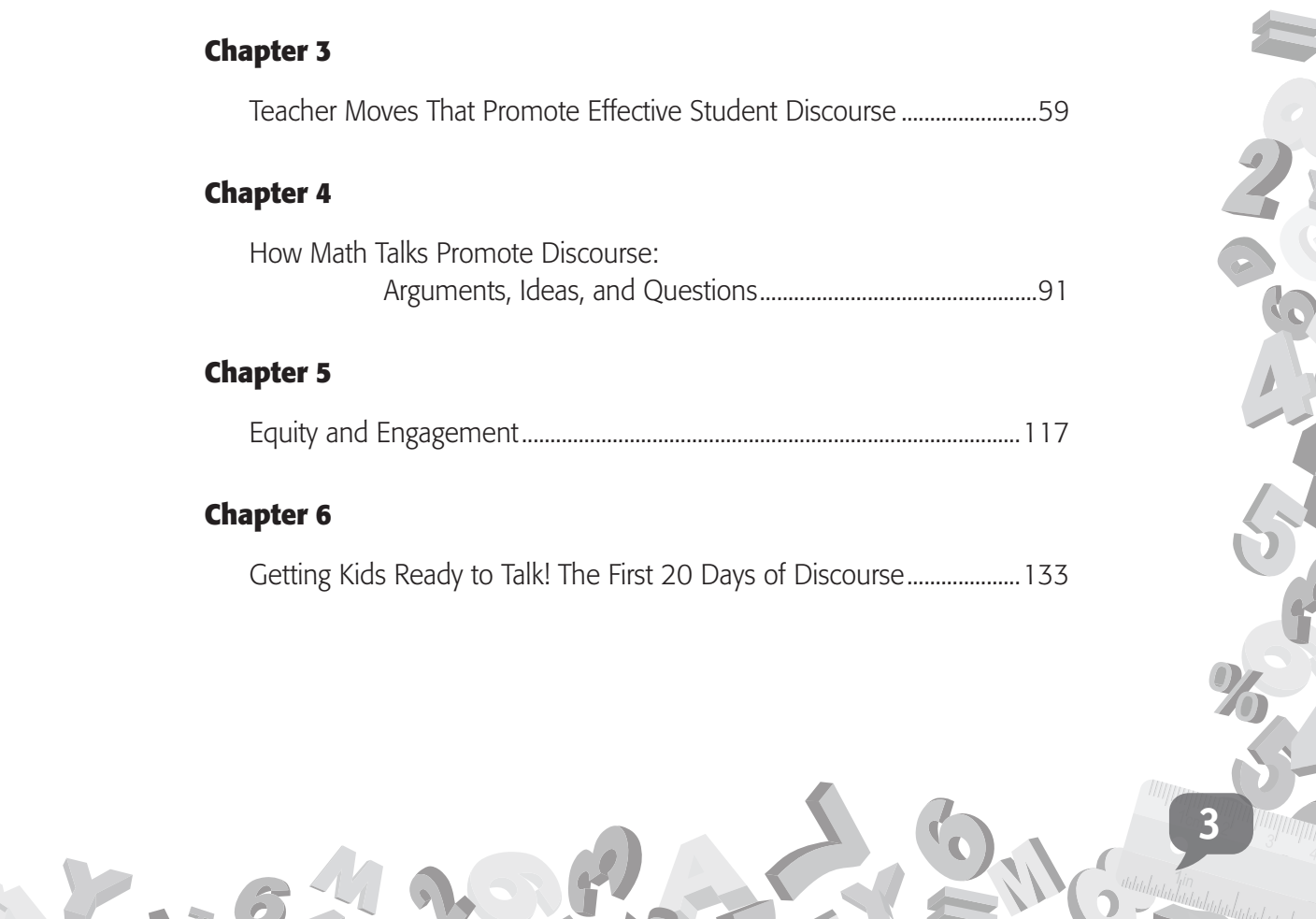
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There is much we know about how to significantly improve the teaching and learning of mathematics. We know that when students are productively engaged, learning is an almost automatic byproduct. We also know that student engagement emerges most effectively from our questions and queries which open doors to student discourse. That is, it is student talk—to their classmates, with their teachers, in small groups—that is a critical component of effective teaching and learning. However, as with all aspects of effective teaching, maximizing the quality and quantity of student discourse takes practice, time, listening, trust, and a commitment to our students. That's where this readable, insightful, and helpful book comes in to play.

Effective and productive discourse does not emerge from a bunch of random questions posed to our students, nor from mindsets that teaching is primarily a process of telling, showing, and practicing. Rather, the higher levels of student learning that *do* emerge from powerful discourse within classroom communities of engaged learners requires intentionality with our tasks and questions, careful listening, and focused mindsets about empowering students. Once again, this is much more easily said than done. But how we implement these and other critical aspects of teaching are thoughtfully described and illustrated in this book.

Building a discourse-rich classroom often starts with Math Talks or number talks. Such Math Talks are safe and relatively easy ways to create a classroom culture of discourse and Chapter 4 can easily stand alone as a valuable summary of the what, why, and how of using Math Talks. Similarly, Chapter 6, where one finds 20 lesson plans to launch the school year serves as a great summary—call it a mini-math-methods course—of how to institute a range of practices and strategies that characterize effective mathematics classrooms. It too can serve as a self-contained initiator of discussions and action planning as part of grade-level teams, PLCs, and faculty meetings.

As noted in Chapter 5, “equitable participation...does not happen automatically. Teachers need to be willing to let go of the expert/evaluator role to give students opportunities to take risks and share what they think. This can be difficult for many teachers” (118). When we are honest with ourselves, we acknowledge how true this

Foreword *(cont.)*

is and what a challenge it can be to “embolden students into a meaningful discourse community” (18). Throughout *Mathematical Discourse: Let the Kids Talk!*, Barbara Blanke gives us a road map for meeting this challenge and for significantly enhancing the quality and impact of student discourse in our mathematics classrooms.

The best teachers I know and observe understand that their greatest challenge is to be learners themselves, deep thinkers and reflectors, and risk-takers. The chapters that follow provide a wide range of guidance to all teachers who aspire to meet this challenge.

—Steve Leinwand

Principal Research Analyst
American Institutes for Research





Acknowledgments

This book has been a longtime dream that began with the children I had the privilege to teach and learn from throughout my years as a K–12 teacher. When I first saw my elementary students blossom in a discourse-rich environment, I began the journey to make that environment a reality in my mathematics classroom! I was very fortunate to learn from several special people. My insights in student-centered teaching began with Mrs. Donna Burk, master teacher, author, and teacher-of-teachers extraordinaire. She led me to the path of teaching other teachers in the field of mathematics and introduced me to the Math Learning Center professional development team.

Through the incredible minds of Dr. Gene Maier, Dr. Albert Bennett Jr., Allyn Fisher, Linda Foreman, Jill Board, Trudy Mitchell, Debby Head, Libby Pollett, Michael J. Arcidiacano, Mike Wong, Pat Wong, and Kathy Pfaendler, my journey to learn more about teaching math began. The late Dr. John Van de Walle joined this elite group by becoming an email buddy who supported my first writing experiences and provoked me to think deeper about the mathematics I taught. I give gratitude to Steve Leinwand who always modeled the voice I wanted to develop throughout my career as a math educator; always talking about sensible mathematics. I am a believer that I must deliver a message to provoke action, and you have been my inspiration for many years. A huge influence in my career has been the research work of Virginia Bastable, Deborah Schifter, and Susan Jo Russell, who made me think deeply about how computational fluency influences student algebraic reasoning. All of these educators pressed me to make sense of the math and helped me to develop an appreciation of the beauty that lies in the mathematics we teach. Without them, my journey would have never begun.

I thank my colleagues and friends who taught me to persevere and enjoy the process of the journey; especially, Jill Laursen, Kimberly Kelly, Jessica Djuric, TJ Jemison, Dr. Susan McBride, Dr. Boyce Heidenreich, Amy Shields, Pia Hansen, Martha Ruttle, and Dr. Barb Bamford. The passion of these mentors for teaching is evident in the students' lives they've touched. Together, I believe we have altered the belief systems and mindsets of teachers and students relative to teaching and learning mathematics. I give special thanks to Dr. Karen Higgins, my doctoral advisor, mentor, and friend who convinced me

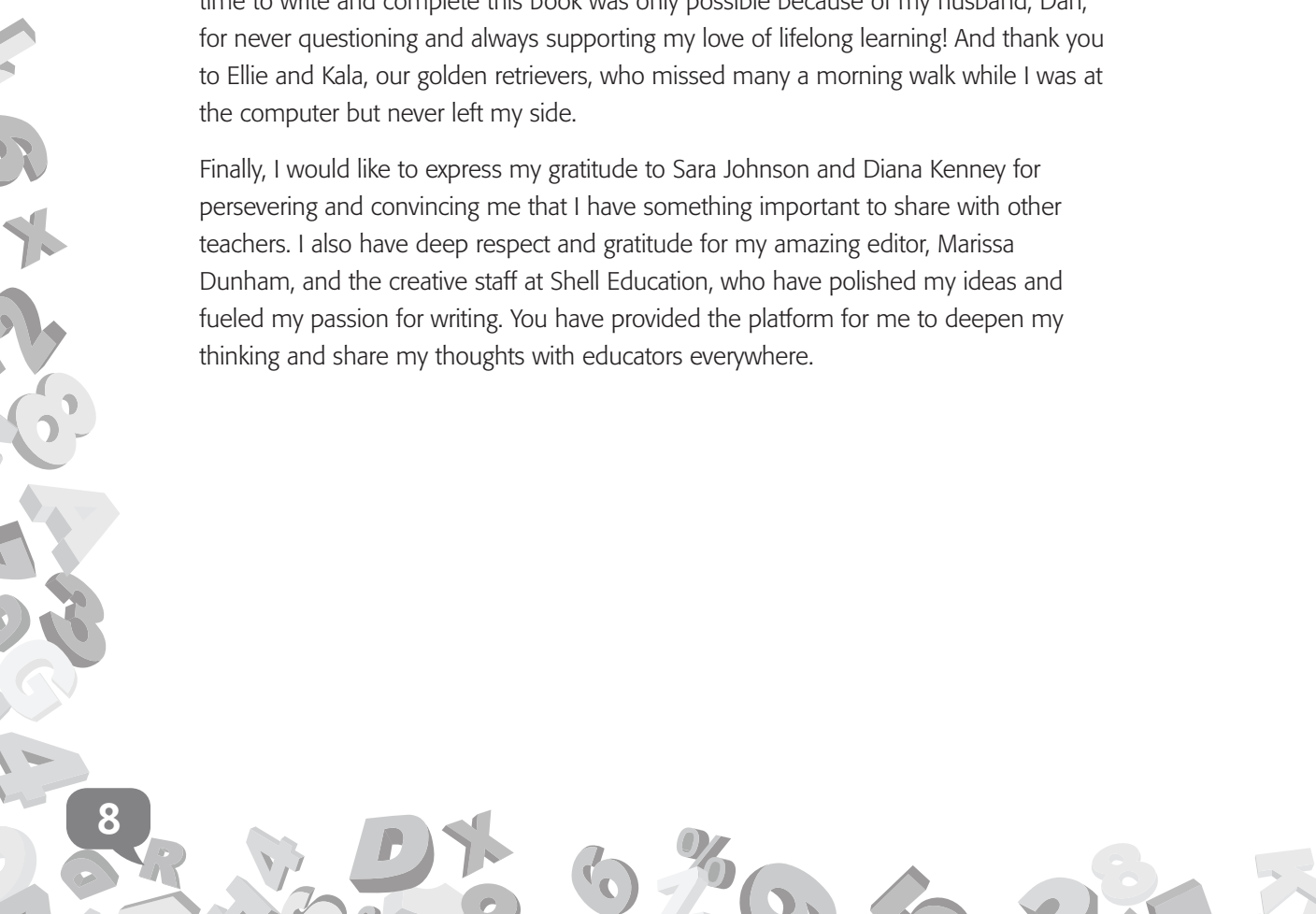


Acknowledgments *(cont.)*

that researching discourse was important and believed in me as a teacher-educator and researcher. I also give a special thank-you to Cary Cermak-Rudolf who opened the door to her classroom every day for four months so that I could deeply understand and see mathematical discourse in action! I am forever indebted to you! And to all the teachers and students who have continually opened their classroom doors and invited me in so that I could continue to learn with and from them, you are all amazing teachers and the children's lives you touch have been forever changed!

I have special appreciation and love for my parents, Paul and Eleanor Creger, who raised a lifelong learner from the beginning and taught me to embrace learning and do everything with a passion for life. Thank you to my best friends, Susan Roberts and Dr. Bonnie Markoff, for reading, editing, taking care of my dogs, and being genuinely excited for me throughout this writing process. You are my family! And of course, having the time to write and complete this book was only possible because of my husband, Dan, for never questioning and always supporting my love of lifelong learning! And thank you to Ellie and Kala, our golden retrievers, who missed many a morning walk while I was at the computer but never left my side.

Finally, I would like to express my gratitude to Sara Johnson and Diana Kenney for persevering and convincing me that I have something important to share with other teachers. I also have deep respect and gratitude for my amazing editor, Marissa Dunham, and the creative staff at Shell Education, who have polished my ideas and fueled my passion for writing. You have provided the platform for me to deepen my thinking and share my thoughts with educators everywhere.





Introduction

Each time one prematurely teaches a child something he could have discovered himself, that child is kept from inventing it and consequently from understanding it completely.

—Jean Piaget 1970a, 715

My goal for writing *Mathematical Discourse: Let the Kids Talk!* is to support teachers choosing to shift their mindsets about how they were taught math and were taught to teach math and to encourage them to begin using discourse to help their students understand and make sense of mathematics. So many of us were taught to explain, or show and tell, students what they needed in math, and we just crossed our fingers and hoped that they would learn it. We taught math and then assessed our students to see what they could and could not do, and we proceeded to teach them what we thought they needed to strengthen the desired behavior of coming up with a correct solution. We were encouraged to offer “hands-on” learning to induce “correct” understandings. Yet, many of our students fell behind and did not learn what they were supposed to master, and we moved on to make sure we covered the skills. This book’s purpose is to support any educator who desires to shift his or her practice by becoming a reflective practitioner and promote discourse opportunities as a way to develop a deeper understanding of mathematics for all students. Inventing and understanding are critical to the development of a positive growth mindset. When we, as teachers, learn to foster disequilibrium, puzzlement, discourse, reflection, and argumentation, we are encouraging students to reason about mathematical ideas. We are using talk as a means to help students to think on their own. They no longer need the teacher to explain, or show and tell.

As teachers, we have to recognize what these necessary shifts in our mindsets are that will enable us to transform our classrooms into mathematical learning communities where students seek to deeply understand mathematics. The Common Core State Standards of Mathematical Practice and state process standards guide us to make certain all students persevere in solving mathematical problems with tenacity and confidence.



We use tools strategically, explore mathematical structures using visual models, attend to precision, and pose viable arguments to critique ideas to nurture student academic growth. Creating a classroom environment conducive for students to generate a depth of understanding of mathematics—rather than being told how to get to the answer—is critical. We, as teachers, have a new role: one of facilitator and mentor, rather than explainer. We want to teach our students to do more than a share-and-tell, we want them to talk about and justify their ideas, build mathematical arguments, and defend their thinking. The questions we should be asking are: How do we support this kind of classroom on a daily basis? Where should we begin? How do we learn to *Let the Kids Talk!*?

My purpose in writing this book on mathematical discourse is to empower teachers everywhere to believe in and nurture their students' ideas, questions, and arguments as budding mathematicians to become autonomous learners in their K–12 classrooms. It was in my own classroom that I experienced the influence of mathematical discourse. It was there that I learned with and from my students rather than delivering knowledge to them. My students taught me to slow down and listen to their ideas. It was my students who nurtured and challenged me to embrace my role as a co-learner and to ask, “Is there another way to support ALL of my students as they make sense of mathematics and develop the habits of mind of a mathematician?”

This book offers a brief history of mathematical discourse and takes you through specific strategies, methods, instructional approaches, resources, and activities to use with your students as they learn to make sense of mathematics on a daily basis.

The chapters include the well-researched and studied effects of discourse over the years, as well as various strategies, routines, teacher moves, and questioning techniques that will support you in transforming your classroom into a discourse-rich environment. The following chapters are discussed:

- Chapter 1, *What Is Mathematical Discourse?*, shares a brief history of mathematical discourse, some patterns that continue to influence how we teach mathematics, and why it is important to consider shifting our mindsets and teaching practices to include discourse in today's math classrooms. We explore how this knowledge can assist you in promoting mathematical conversations with your students.

- Chapter 2, *Discourse and Mathematical Practice and Process Standards*, highlights how sharing ideas, asking questions, and reasoning about mathematical ideas support the habits of mind that ALL students need to develop to meet mathematical practice and process standards. It provides various and specific strategies for you to build a discourse-rich community of learners.
- Chapter 3, *Teacher Moves That Promote Effective Student Discourse*, reminds us of the thousands of teacher decisions and pedagogical moves that we make daily in our math classrooms and how we can learn to reflect and act upon them to promote productive, healthy risk-taking, while building a discourse-rich community of mathematical learners.
- Chapter 4, *How Math Talks Promote Discourse: Arguments, Ideas, and Questions*, explores what specific teacher talk moves can be implemented during Math Talks, a daily routine, which offers equitable opportunities for all students while engaging in mathematical discourse. It answers the question: How do we begin to get our students to talk, justify, critique, and challenge each other about their mathematical thinking?
- Chapter 5, *Equity and Engagement*, continues the discussion about how our teacher beliefs and knowledge of our students impact student engagement with cognitively demanding tasks in an inclusive and safe classroom environment. We look at the strategies that will help you turn routine math problems into non-routine problems through the use of mathematical discourse; thereby, providing equity for all students.
- Chapter 6, *Getting Kids Ready to Talk! The First 20 Days of Discourse*, provides a day-by-day guide that answers the questions: How do I get my students to talk mathematically in my classroom? Where do I start? How do I fit this in with all the content that I must cover? This day-by-day guide will show both elementary and secondary teachers how to build community and establish necessary norms to create a discourse-rich environment where students take risks, justify their strategies, and question and clarify mathematical ideas all while deepening their understanding of mathematics.

As teachers, we all have a strong desire to meet our students' needs, and we can begin to do that by believing mathematics can be accessible for all through the use of discourse. When we choose to learn together, we engage in discourse and communicate our thoughts and feelings about what it means to be effective teachers and learners of mathematics. It is a great privilege for me to use this book as a vehicle to continue the conversation and collaborate with teachers everywhere to deepen our collective thinking and learning, to create a fascination about what others think and do, and to begin to think about how other people's thoughts might influence our own ideas and understanding. It can be joyful and enlightening to ask questions, hear heartfelt "Ahas," and see frustrating roadblocks give way to ideas that have been there all along. My dream is that this book is a stepping-stone for teachers to begin the conversation and take the first steps toward building equitable learning environments where everyone, students and teachers alike, develop the habits of mind to blossom into lifelong learners...as mathematicians.



The paperfolding lesson resource and student Math Talk reflection pages in this book are available as digital PDFs online. A complete list of the available documents is provided on page 182. To access the Digital Resources, go to: www.tcmpub.com/download-files. Enter this code: 84715886. Follow the on-screen directions.



What Is Mathematical Discourse?

What does it mean to do mathematics, and why do so many of our students dislike learning it in the classroom? This is a question that pops up more often than it should. There is an uneasy resistance to math that boggles the educational mind and leaves us wondering why. Why such anxiety? One reason could be that math is seen by most students (and sometimes parents and guardians) as different from other subjects. Math is frequently taught as a performance subject, where getting to the correct solution is the only goal. They see the math that they do in the classroom setting as something disconnected from their world. For many, doing math in school is only that—doing. It means completing worksheets and getting answers, and rarely do students think about or desire to see the beauty of mathematics, to share ideas, to ask questions, to struggle productively, or to look for rich connections that can make math applicable to the real world. The nature of mathematics does not make it different, as many believe; instead, it is due to the widespread misconception that mathematics is a subject of rules and procedures, using strictly numbers, recalling facts quickly, and being fast to get right versus wrong answers. Teachers who believe in promoting mathematical discourse have seen students begin to change this baseline traditional view of mathematics and begin to see mathematics as a creative, visual, connected, and exciting subject. Students who engage in mathematical discourse are given this opportunity in many different ways. Ultimately, it is you, the teacher, who shapes mathematical learning for students you teach. The first step is to understand what mathematical discourse means.

Facilitating student engagement in mathematical discourse can be both revitalizing and demanding. It can be easy to get a conversation going by asking students to share their ideas or strategies to the class. Though their ideas often amaze us as educators,

mathematical discourse goes beyond students performing a show-and-tell of strategies and solutions. It's more than the class merely listening and clapping and then moving on. Knowing what to do with students' ideas and teaching them how to meaningfully ask challenging and clarifying questions during discussions can be quite critical. If done well, mathematical discourse can shape teachers' and students' perceptions of themselves as mathematicians, as well as their ideas about what being a mathematician involves.

According to Deborah Ball:

Discourse is used to highlight the ways in which knowledge is constructed and exchanged in classrooms. Who talks? About what? In what ways? What do people write down and why? What questions are important? Whose ideas and ways of knowing are accepted and whose are not? What makes an answer right or an idea true? What kinds of evidence are encouraged or accepted? (1991, 44)

NCTM (2000) defines mathematical discourse as both students' and teachers' ability to articulate mathematical ideas or procedures via talking, writing, asking questions, and responding to ideas. These are realized through various configurations in the classroom in Figure 1.1:

Figure 1.1 Student-Teacher Relationships in Mathematical Discourse

Definition	Explanation
Student-to-Teacher	The student primarily addresses the teacher even though the entire class or group hears the student's comments.
Student-to-Student	The student addresses another student.
Student-to-Group/Class	The student addresses a small group of students or the entire class.
Individual Reflection	The student documents his or her reflections about mathematics in writing.
Teacher-to-Student	The teacher addresses the student(s).
Teacher-to-Group/Class	The teacher addresses a small group of students or the entire class.

As we see, effective mathematical discourse is an interactive process. Students engage in various types of discourse at different cognitive levels, deepening their questions to lead to explanations and justifications that may be challenged, defended, or clarified. Students can thereby form new generalizations, initiating new conversations.

Most notably, it is the student who is in control of the conversation, and the teacher's role is that of discussion facilitator. It is these student-to-teacher questions, generated from conversations, which lead to explanations and justifications that may be challenged, clarified, and defended within the discourse classroom community. During discourse, students will often make new generalizations and conjectures that initiate a deeper level of student communication through the discussion of ideas, strategies, and thinking. These are some of the important things discourse provides: ways to scaffold mathematical thinking into the curriculum for *all* students. After all, it is the teacher who plays the crucial role in shaping discourse with signals to their students about how to value mathematical knowledge as well as ways to think about and know mathematics (Ball 1991; Blanke 2009).

It can be tricky to create and maintain discourse environments in the classroom for many teachers (Sherin 2002). Often, it's not enough to encourage students to discuss ideas and converse with each other. Teachers must also ensure discussions are mathematically productive and continually scaffold student academic growth. Asking teachers to use discourse requires teachers to develop a new sense of what it means to teach mathematics and to be effective, successful mathematics teachers (Sherin 2002; Smith 1996). At the same time, teachers must want to better understand their roles in developing discourse and make the choice to change to effectively implement mathematical discourse daily in their math classrooms. The choice to develop discourse communities can be nurtured through shared ideas and the desire to continually learn.

A Historical Perspective on Mathematical Discourse

We work in the fog of collective amnesia.

—Treisman 2016

Mathematical discourse is not a new idea! A careful study of mathematical history uncovers the fact that many ideas that have been called new are actually old, being revisited and reapplied into a broadened mindset. The examination of studies and research of the past has also contributed to current research of the effective usage of discourse in mathematics education. Unfortunately, there continues to be obstacles

in implementing research-informed instructional practices, such as discourse, in our classrooms. A brief look at the history of mathematical discourse points out that mathematics education continues to be cyclical. This lens gives insights into the factors that may still be in contention today, the influences that continue to alter instruction, and the motives and conflicts that shape the present day learning of mathematics.

Studying our knowledge of the past empowers us to speak with more authority and to make better-informed decisions about our everyday practices in the classroom. History can offer a better insight into the influence of mathematical understanding and mathematical discourse on student learning and classroom teaching. Realizing this vision of classroom discourse in mathematics education has proven to be challenging to implement over the years. This supports the importance of studying how teachers develop and sustain mathematical discourse communities, and it supports the goal of developing a deep mathematical understanding for all. It is a goal of this book to offer teachers ways to support mathematical discourse in their math classrooms and encourage all students to construct viable arguments with others because learning is a collaborative endeavor that emphasizes the importance of every student's depth of understanding.

As stated in NCTM's *Principles to Actions: Ensuring Mathematical Success for All* (2014), there are dominant cultural beliefs about teaching and learning mathematics that sometimes get in the way of implementing best practices, such as mathematical discourse, in our classrooms. Developments in the mid- to late-nineteenth century have profoundly influenced our knowledge with regard to how students learn and understand mathematics. The very first American school mathematics textbook was Nicolas Pike's *New and Complete System of Arithmetic—Composed for the Use of the Citizens of the United States* (1788). Pike's teaching process was 1) state a rule, 2) give an example, and 3) have students complete a set of practice exercises. This scripted approach established a method of delivering mathematics to students that was rigid and has become deeply rooted in educational culture. Many today still live in the shadow of these ideas and stereotypes about learning arithmetic that was articulated so long ago.

The first attempt to change instruction was offered by Colburn's (1849) discovery learning, which offered the idea for teachers to postpone student practice until after students had developed a deeper conceptual understanding of mathematics. This began the movement toward the use of discourse and talking about mathematical ideas. His idea was expanded upon again by Charles Davies (1850) and Edward

Brooks (1880). Davies and Brooks discussed how student understanding and thinking could be strengthened through the act of studying and talking about mathematics to cultivate one's mental abilities (Bidwell and Clason 1970). A backlash to Colburn's ideas was quick and reminiscent of today's math clashes. The outcry became that rules were necessary and students could not be expected to invent them. New publications proclaimed that they would satisfy parents who longed for arithmetic to be taught "the good old fashioned way" with concise and plain explanations of rules. Today, this is still somehow a serious roadblock for developing productive discourse in mathematics.

Secondly, arithmetic became formalized through the creation of a logical system of definitions, principles, and theorems. This led to mathematics being taught based on quantity, which allowed mathematical and psychological theory to blend. The belief was students learned mathematics from a quantitative reality via student perception and intuition. Through these ideas, knowledge was built through reasoning and imagination. William Brownell's *Meaning Theory of Learning* (NCTM 1935) proposed the ultimate purpose of arithmetic instruction is the development of the ability to think in quantitative situations. The word *think* is used cautiously; the ability to merely perform certain operations mechanically and automatically is not enough. Students must be able to analyze real or described quantitative situations (NCTM 1935, 28).

The third development in mathematical discourse is an emphasis on using manipulative objects in early number work to better understand mathematics. Toward the end of the nineteenth century, the impact of this "new" psychology on mathematics teaching was presented by William James in his book *The Principles of Psychology* (Boring 1957). James provoked an extensive reevaluation of what mathematical content should be taught and why. He spoke to the debate about the origin of the meaning of *number* by asking: Does number exist without any sensemaking by the user, or does meaning evolve from the human mind? (Bidwell and Clason 1970).

So, within the first half century of the founding of the United States, the great school of mathematics debate was underway. Should teachers give students rules and facts to memorize? Or, should they offer problems to talk, argue, discover, and develop a deep understanding of the underlying mathematical principles?

During the twentieth century, and extending into the present day, the teaching of mathematics in American schools has continued this debate and experienced identifiable phases, each with a different emphasis (see Figure 1.2 on page 18).

Figure 1.2 Phases of Mathematics Education and Psychological Learning Theories

Phase	Main Theories and Theorists	Focus	How Achieved
Drill and practice (~ 1920–1930)	Connectionism or associationism (e.g., Thorndike)	Facility with computation	Rote memorization of facts and algorithms Break work into series of small steps
Meaningful arithmetic (~ 1930–1950s)	Gestalt Theory (e.g., Brownell, Wertheimer, van Engen, Fehr)	Understanding of arithmetic ideas and skills; Application of math to real-world problems	Emphasis on mathematical relationships Incidental learning Activity-oriented approach
New math (~ 1960–1970s)	Developmental Psychology, sociocultural theory (e.g., Bruner, Piaget, Dienes)	Understanding the structure of the discipline	Study of mathematical structures Spiral curriculum Discovery learning
Back to basics (~ 1970s)	(Return to) Connectionism	(Return to) Knowledge and skill development	(Return to) Learning facts by drill and practice
Problem solving (~ 1980s)	Constructivism, cognitive psychology, and sociocultural theory (Vygotsky)	Problem solving and mathematical thinking processes	(Return to) Discovery learning, learning through problem solving
Standards, assessments, and accountability (~ 1990s–2000)	Cognitive psychology, sociocultural theory versus renewed emphasis on experimental psychology (NCLB)	Math wars: concern of individual mathematical literacy versus administration of educational systems	NSF: student, standards-based curricula versus text preparation for state-specified expectations
National Research Council's <i>Adding It Up and Common Core State Standards for Mathematics</i> (~ 2000 to Present)	(Return to) Gestalt Theory (e.g., Brownell, Wertheimer, van Engen, Fehr) and Developmental psychology, sociocultural theory (e.g., Bruner, Piaget, Dienes)	Aim to end the “math wars” by summarizing best practice research on K–8 mathematical learning, defining mathematical proficiency as multidimensional	Standards emphasize skill development and student understanding, reasoning, and problem solving Standards-based assessments force emergence of curricula for depth of understanding

Adapted and extended from Lambdin and Walcott 2007