simulations were really effective in deepening understanding, but not as useful when used for surface learning? (See Chapters 4 and 5 for more on surface and deep learning.) In this case, the strategic deployment of simulations could be important. There are situations like this that we will review in this book as we focus on the balance and sequencing of surface learning compared with deep learning or transfer learning. For now, let's turn our attention to actions that teachers can take to improve student learning. We'll start by directly addressing a major debate in mathematics education: direct instruction compared with dialogic approaches.

Direct and Dialogic Approaches to Teaching and Learning

Debates about the teaching of mathematics have raged for decades. In general, the debate centers on the role of direct instruction versus dialogic instruction, with some teachers and researchers advocating for one or the other. Proponents of both models of instruction have similar goals—student mastery of mathematics. But they differ in the ways in which learning opportunities are organized within the context of a lesson. According to Munter, Stein, and Smith (2015b):

> In the direct instruction model, when students have the prerequisite conceptual and procedural knowledge, they will learn from (a) watching clear, complete demonstrations of how to solve problems, with accompanying explanations and accurate definitions; (b) practicing similar problems sequenced according to difficulty; and (c) receiving immediate, corrective feedback. Whereas in the dialogic model, students must (a) actively engage in new mathematics, persevering to solve novel problems; (b) participate in a discourse of conjecture, explanation, and argumentation; (c) engage in generalization and abstraction, developing efficient problem-solving strategies and relating their ideas to conventional procedures; and to achieve fluency with these skills, (d) engage in some amount of practice. (p. 6)

As the authors note, there are several similarities and some important differences between these two competing models. In terms of similarities, both focus on students' conceptual understanding and procedural fluency. In other words, students have to know the *why* and *how* of mathematics.

Neither model advocates that students simply memorize formulas and procedures. As the National Council of Teachers of Mathematics (2014) states, procedural fluency is built on a foundation of conceptual understanding. Students need to develop strategic reasoning and problem solving. To accomplish this, both models suggest that (1) mathematics instruction be carefully designed around rigorous mathematical tasks, (2) students' reasoning is monitored, and (3) students are provided ample opportunities for skill- and application-based practice.

Munter, Stein, and Smith (2015b) also identify a number of differences between the two models, namely in the types of tasks students are invited to complete, the role of classroom discourse, collaborative learning, and the role of feedback. Figure 1.2 contains their list of similarities and differences. Importantly, these researchers also recognize that teachers use aspects of each model. As they note, "teachers in dialogic classrooms may very well demonstrate some procedures, just as students in a direct instruction classroom may very well engage in project-based activities" (p. 9). They argue that the purposes for using different aspects of each model may vary, and the outcomes may be different, but note that "high-quality instruction must include the identification of both instructional practices and the underlying rationales for employing those practices" (p. 9).

Direct instruction is when the teacher decides the learning intentions and success criteria, makes them transparent to the students, demonstrates them by modeling, evaluates if they understand what they have been told by checking for understanding, and re-tells them what they have been told by tying it all together with closure.

We agree that direct instruction should not be thought of as "spray-and-pray" didactic show-and-tell transmission of knowledge. Neither direct nor dialogical instruction should be confused with "lots of talking" or didactic approaches. John (Hattie, 2009) defines **direct instruction** in a way that conveys an intentional, well-planned, and student-centered guided approach to teaching. "In a nutshell, the teacher decides the learning intentions and success criteria, makes them transparent to the students, demonstrates them by modeling, evaluates if they understand what they have been told by checking for understanding, and re-tells them what they have been told by tying it all together with closure" (p. 206).

EFFECT SIZE FOR DIRECT INSTRUCTION = 0.59

EFFECT SIZE FOR CLASSROOM DISCUSSION = 0.82

When thinking of direct instruction in this way, the effect size is 0.59. Dialogic instruction also has a high effect size of 0.82. This doesn't mean that teachers should always choose one approach over another. It should never be an either/or situation. The bigger conversation, and purpose of this book, is to show how teachers can choose the right approach at the right time to ensure learning, and how both dialogic and direct approaches have a role to play throughout the learning process, but in different ways.

COMPARING DIRECT AND DIALOGIC INSTRUCTION

Dialogic Instruction	Distinction	Direct Instruction
Fundamental to both knowing and learning mathematics. Students need opportunities in both small-group and whole-class settings to talk about their thinking, questions, and arguments.	The importance and role of **talk**	Most important during the guided practice phase, when students are required to explain to the teacher how they have solved problems in order to ensure they are encoding new knowledge.
Provides a venue for more talking and listening than is available in a totally teacher-led lesson. Students should have regular opportunities to work on and talk about solving problems in collaboration with peers.	The importance of and role of **group work**	An optional component of a lesson; when employed, it should follow guided practice on problem solving, focus primarily on verifying that the procedures that have just been demonstrated work, and provide additional practice opportunities.
Dictated by both disciplinary and developmental (i.e., building new knowledge from prior knowledge) progressions.	The **sequencing of topics**	Dictated primarily by a disciplinary progression (i.e., prerequisites determined by the structure of mathematics).
Two main types of tasks are important: (1) tasks that initiate students to new ideas and deepen their understanding of concepts (and to which they do not have an immediate solution), and (2) tasks that help them become more competent with what they already know (with type 2 generally not preceding type 1 and both engaging students in reasoning).	The nature and ordering of **instructional tasks**	Students should be given opportunities to use and build on what they have just seen the teacher demonstrate by practicing similar problems, sequenced by difficulty. Tasks afford opportunities to develop the ability to adapt a procedure to fit a novel situation as well as to discriminate between classes of problems (the more varied practice students do, the more adaptability they will develop).
Students should be given time to wrestle with tasks that involve big ideas, without teachers interfering to correct their work. After this, feedback can come in small-group or whole-class settings; the purpose is not merely correcting misconceptions, but advancing students' growing intellectual authority about how to judge the correctness of one's own and others' reasoning.	The nature, timing, source, and purpose of **feedback**	Students should receive immediate feedback from the teacher regarding how their strategies need to be corrected (rather than emphasizing that mistakes have been made). In addition to one-to-one feedback, when multiple students have a particular misconception, teachers should bring the issue to the entire class's attention in order to correct the misconception for all.

(Continued)

(Continued)

Dialogic Instruction	Distinction	Direct Instruction
Students' learning pathways are emergent. Students should make, refine, and explore conjectures on the basis of evidence and use a variety of reasoning and proof techniques to confirm or disprove those conjectures (CCSS-M-SMP 3), asking questions that drive instruction and lead to new investigations.	The emphasis on **creativity**	Students' learning pathways are predetermined and carefully designed for. To "make conjectures and build a logical progression of statements to explore the truth of their conjectures" (CCSS-M-SMP 3) is limited to trying solution strategies for solving a problem posed to them.
Students' thinking and activity are consistent sources of ideas of which to make deliberate use: by flexibly following students' reasoning, the teacher can build on their initial thinking to move toward important ideas of the discipline.	The purpose of **diagnosing student thinking**	Through efficient instructional design and close monitoring (or interviewing), the teacher should diagnose the cause of errors (often a missing prerequisite skill) and intervene on exactly the component of the strategy that likely caused the error.
Students participate in the defining process, with the teacher ensuring that definitions are mathematically sound and formalized at the appropriate time for students' current understanding.	The introduction and role of **definitions**	At the outset of learning a new topic, students should be provided an accurate definition of relevant concepts.
Representations are used not just for illustrating mathematical ideas, but also for thinking with. Representations are created in the moment to support/afford shared attention to specific pieces of the problem space and how they interconnect.	The nature and role of **representations**	Representations are used to illustrate mathematical ideas (e.g., introducing an area model for multi-digit multiplication after teaching the algorithm), not to think with or to anchor problem-solving conversations.

Source: Munter, Stein, and Smith (2015b). Used with permission.

Figure 1.2

Precision teaching is about knowing *what* strategies to implement *when* for maximum impact.

Many readers of *Visible Learning* (Hattie, 2009) attend to the details about effect sizes and measuring one's impact (important, to be sure), but fewer may notice that this body of research points to *when* it works as well as *what* works. Knowing *what* strategies to implement *when* for maximum impact is what we think of as **precision teaching**.