If in a time crunch, focus on red bracketed sections (but reading the methodologies in green is also useful).

Chapter 6
Self-Explaining

INTRODUCTION

I suspect you could theoretically survive parenting a child without ever raising your voice in anger—an achievement I certainly can't claim to have made. All the restraint you may have demonstrated in the early years of parenting, however, will melt when your child begins learning to drive, and you find yourself in the passenger seat of a terrifying death machine with a 16-year-old at the helm. No matter how carefully they have studied the rules of the road and practiced in parking lots, 16-year-olds who are learning to drive do things like ignore yield signs or forget to look in both directions before pulling out into traffic. At those moments you can choose either to raise your voice or to crash.

I have chosen to raise my voice.

However justified I may feel in barking an emergency instruction in potentially hazardous driving situations, my 16-year-old daughter does not seem to appreciate the value of what I am doing for us both (i.e., saving our lives). This means that driving lessons, which I have just recently completed with my second child, consist of tension-filled rides around the neighborhood in which I am continually on the verge of a panic attack and she is continually on the verge of tears. During the time when I was supervising these white-knuckled drives, I also happened to be doing some reading about self-explanation and learning, the basic premise of which is that *learners benefit from explaining out loud (to themselves or others) what they are doing during the completion of a learning task*. Less to improve her learning than to diffuse the tension in the car, I began asking my daughter to tell me about what she was doing as she drove. One of her problems had been that she tended to drive too close to the right side of the road, perhaps out of an exaggerated (and understandable) concern for not drifting into oncoming traffic. When I asked her to talk about what she was doing as she drove, she noticed this issue herself, about which I had reminded her earlier (like a thousand times), and she made a self-correction. She navigated more to the center of the road. This happened several other times with other driving tasks. Whenever I asked her to explain what she was doing, she would analyze her own driving in ways that didn't seem to happen when she was just sitting there attempting to navigate the road and waiting for me to shout at her. It's a strategy I won't soon forget, since I still have three more children who will turn 16 sometime in the not-too-distant future.

This helpful incident was my first real observation of the power of self-explanation, a learning strategy that can assist students who are attempting to master a cognitive skill. As we saw in the last chapter, the absolutely most helpful thing that learners need to do to master a skill is to practice it as frequently as possible. For this reason novice drivers like my daughter are required by my state to have 40 hours of practice behind the wheel between the time they get their learner's permit and the time that they can apply for a driver's license. Nothing substitutes for hours and hours behind the wheel, but we saw in the second half of the last chapter the importance of practicing mindfully, of stepping away from rote exercises as frequently as possible to monitor one's performance, to seek opportunities for improvement, and to explore alternative strategies or perspectives. Instructors can play an essential role in nudging learners toward this mindful learning when they are present at skill-based practice sessions. Self-explanation represents one very simple technique for fostering mindful learning during skill-based practice, but it also can help improve comprehension by requiring learners to make connections between their knowledge and their skills. The best self-explanation techniques prompt learners to articulate not only what they are doing but also *why* they are doing it, and that second requirement helps ensure that students can't simply connect the dots to make a picture: they must tie their doing to their knowing. As such, it has the power to draw together the aims of the previous two chapters in this part—and can do so in the kinds of easy, simple-to-use exercises that are the hallmark of small teaching.

IN THEORY

The first major study to demonstrate that self-explanations can support learning did so in an effort to analyze how students learned from worked examples—in other words, from sample problems that had been worked out in advance and then were reviewed step by step for the benefit of the students (Chi, Bassok, Lewis, Reimann, and Glaser 1989). In tackling this issue, this study explored a fundamental paradox at the heart of learning from examples more generally. Plenty of research demonstrates that students benefit from the use of examples in learning rather than simply being presented with theories or ideas or principles. An equally robust body of literature also demonstrates that students who learn from examples often have trouble transferring their knowledge acquired from examples to new contexts. This problem becomes especially acute when learners are attempting to use knowledge gained from examples to solve new problems. As the authors of the study explain, "students who have studied examples often cannot solve problems that require a very slight deviation from the example solution" (Chi, Bassok, Lewis, Reimann, and Glaser 1989, p. 148). Although studying worked-out examples can help students solve future problems that are *isomorphic* (i.e., taking the same form as the original problem), doing so often does not translate well into helping students solve problems that require *far transfer* (carrying principles or theories from the initial context to a completely new context). The researchers in this case, led by Michelene T. H. Chi, argued that worked-out examples often elide steps or fail to articulate conditions that are important for the learner to understand. To help them fill in those gaps, they hypothesized that learners who self-explain while they are studying worked examples—doing things like monitoring their comprehension, or paraphrasing the textbook, or stating the relevant principles out loud—would improve their ability to solve future problems.

Their experiment consisted of two phases: a first one in which their subjects studied a series of worked-out examples from a physics textbook and answered questions to test their declarative knowledge; and a second phase in which they were asked to solve problems based on that knowledge. In this experiment the researchers did not so much prompt self-explanation as listen for it; they wanted to see if differences in understanding and problem solving would be tied to spontaneous self-explanations generated by the learners. The subject size was small, just 10 students, who were ultimately divided into two groups: *Good* and *Poor*. The Good students had a mean success rate of 82 percent on the problems, whereas the Poor students came in at 46 percent (p. 158). The difference in the amount of self-explanations generated by the two groups is startling: Good students offered around 140 lines of self-explanation in the transcripts, whereas Poor students generated only around 20 (p. 159). Not wanting to rely simply on volume of words, though, the researchers looked more carefully at the self-explanation transcripts and eliminated less relevant comments to tabulate only those that connected to the major ideas of the subject matter. The differences narrowed but remained quite strong: 51 for the Good students versus 18 for the Poor (p. 159). The really astonishing point about these results is that the first phase of the study showed almost no differences between the Good and Poor students in terms of their declarative knowledge of the physics principles in question. In other words, all students could score equally well when they were asked to do things like provide definitions; the stark differences between the two only emerged when they had to apply their declarative knowledge to solving problems.

When they explored what types of comments the Good learners actually made during their self-explanations, they found three basic categories of material. First, and most important, the Good learners generated *explanations*. As they described such statements, “Explanations consist of inferences about the conditions, the consequences, the goals, and the meaning of various mathematical actions described in the example. Furthermore, a large number of explanations that the Good students provided were judged to be guided by the principles, concepts, and definitions introduced in the text” (p. 169). Good learners, in other words, made explanatory statements that tied specific problems to general principles; they connected knowing and doing. Second, the Good learners frequently *monitored comprehension*. In other words, they stated whether or not they understood what they were reading and were not shy about admitting when they were stuck. “Good students,” they suggested, “realize that they do not understand more often than the Poor students” (p. 172). Most important, when the Good students recognized and articulated gaps in their understanding, they sought to correct them. The final category included all other types of substantive statements the students might have made, including *paraphrasing*. Good students restated different aspects of the problems in their own words. In all of these areas, the researchers ultimately argue, the Good students were improving their problem-solving abilities and were linking their knowledge to problem-solving skills by creating what they call “inference rules” (p. 177). By this they mean that learners are gaining a clearer understanding of how to apply principles within different contexts. Inference rules “spell out more clearly the specific conditions or situations in which a specific action is to be taken” (p. 178), which helps learners recognize when learned principles might apply to novel contexts.

Ultimately, the authors of this study concluded that “self explanations not only construct better problem-solving procedures, but they also help students to understand the underlying principles more completely” (p. 169). This study was incomplete in that it relied on the students to generate those self-explanations, which would have limited use for us as college and university instructors. Obviously we could advise students to engage in self-explanations while they are studying examples in our textbooks, but we advise students to do lots of things, many of which they ignore. The question then arises as to whether self-explanations generated in response to prompts from a teacher would have the same effect as self-explanations spontaneously generated by the students. It may certainly be the case, after all, that self-explanations worked for the Good students in Chi et al.'s initial study because those Good students were good students and self-explanation was simply one of a package of activities in which they engaged that helped them learn. However, if you isolate the single activity of self-explanation and require students of all levels to employ it in their learning activities, will it still have the same powerful effect that it had in this original study?

This was the question that Chi and another set of colleagues asked and answered in a second experiment conducted several years later with another group of students, this time shifting the content from problem solving in physics to understanding the circulatory system in the human body. The purpose of this revisitation of the self-explanation effect, they explained, was to extend it "from skill acquisition to the learning of a coherent body of new knowledge" and to see whether "the beneficial effect of self-explanations can be achieved merely by prompting students to self-explain" (Chi, DeLeeuw, Chiu, LaVancher 1984, p. 442). This study has the greatest implications for us as instructors because—if prompting self-explanation demonstrates the same powerful learning effects as spontaneously generated self-explanation—it gives us the opportunity to incorporate it into our teaching practices. Unfortunately, this study shifts us away from college-level students, but it does so as a part of a larger effort by the authors to test the extent to which the positive learning effects of self-explanation identified in the first study would appear under an entirely different set of conditions. In this second study, they worked with a new age group (eighth graders), a new discipline (biology), and a new type of learning (text comprehension versus problem solving), and they prompted self-explanations rather than simply observing students generating them spontaneously. They make a good argument that these represent such a complete set of differences from the first study that if they observe the same learning effects, self-explanation has powerful potential as a teaching strategy for instructors at all levels.

In the study, eighth graders were asked to read brief passages from a high school biology textbook about the human circulatory system and were prompted to self-explain what they were learning after each sentence they read. A second group of eighth graders were asked to read the same passages from the textbook twice but without self-explanation prompts. (This second reading ensured that they spent equal amounts of time on the text as the self-explaining students.) The students who were prompted to self-explain did so in three ways: they were instructed in advance to self-explain after they read each of the 101 sentences of the passage; every few sentences they were prompted to answer a question about the *function* of the circulatory system part they were learning about (i.e., what is the function of the septum?); they were occasionally asked by the researchers to clarify or elaborate on their initial self-explanations. Both sets of students were given pretests on the circulatory system and then tested a week after their study sessions. In these final tests, students were asked multiple types of questions about the material they read: some required memorization of basic information about the circulatory system (i.e., “What does hemoglobin transport?”), and others required them to make inferences about the system based on what they had learned (“Why doesn't the pulmonary vein have a valve in it?”). A final category of questions required them to make even more complex inferences about the implications of the circulatory system for human health (such as how the circulatory system would account for the effects of a poisonous snake bite). This range of questions seems to mimic what students typically find on exams in higher education, testing students on both memorization and more complex critical thinking skills (p. 448).

The study results confirm the findings of the first experiment. The self-explanation prompted students experienced a 32 percent gain in their knowledge of the circulatory system from the pretest to the posttest, whereas the unprompted students experienced a 22 percent gain (p. 453). Parsing the results a little more finely, Chi and colleagues noticed that the improvement was slightly more extensive on the more complex questions. In the third and fourth question categories, the prompted students improved 22 percent from pretest to posttest, whereas the unprompted students improved only 12 percent (p. 453). The study also looked at the volume of self-explanations offered by those in the prompted group, separating them out into high and low self-explainers. Even in this more finely tuned analysis, the differences persisted. Analyzing both self-generated drawings made by the students and their verbal explanations to see how they reflected an accurate mental model of the circulatory system, they found that the high self-explainers were much more likely to develop such an accurate model than the low self-explainers. “Eliciting self-explanations,” they conclude, “clearly enhances learning and understanding of a coherent body of new knowledge, whether one compares the amount learned by the prompted and unprompted students, or whether one compares the amount learned by the high and low self-explainers” (p. 469). Good students, in other words, may naturally self-explain more than weaker students; however, we can still help those weaker students by prompting self-explanations.

how do mentors prompt self-exp?

Before shifting to our models, consider one final and more recent study on the role of self-explanation, this one working with students who were learning how to solve probability problems in statistics in an online environment. The researchers had students review worked examples and then solve a succession of problems online, some of which included prompts for self-explanation and some of which did not. In the self-explanation condition, “the learner was encouraged to self-explain each solved solution step by first examining the step and then identifying which principle of probability the step exemplified” (Atkinson, Merrill, and Renkl 2003, p. 777). This meant literally that the learner saw, prior to her attempt to resolve each new step of the solution, a drop-down menu containing several possible principles that might be relevant for that step and that she had to select one of them before proceeding. It's worth noting what a weak form of self-explanation this is: simply prompting learners to stop and select the relevant principle rather than requiring them to articulate it themselves. Yet, in spite of the very diluted form of self-explanation in which these learners engaged, the positive learning effects appeared strongly in the students' ability to solve problems on a posttest in both near-transfer problems (ones similar to ones they had just studied) and far-transfer problems (ones that stemmed from similar principles but had few similar surface features).

The researchers noted in their discussion that the students received immediate feedback on their selection of the principle, and they theorized that this might be a crucial step—a point worth mentioning in considering how to translate self-explanation into small teaching activities. Overall, though, the study confirms Chi et al.'s findings that self-explaining while learning to solve problems, even in modest ways, can provide a significant learning boost. We are left, then, with only one final question: Why does self-explanation work?

Chi and her colleagues theorized in the first study that self-explanation may benefit learning because worked examples can never fully explain *every* step necessary to the solving of a problem. Some steps are taken for granted, whereas others might make sense only to those who have certain background or contextual knowledge in place already. Self-explanation enables learners to fill in the gaps of these unarticulated steps when they are studying worked examples; without a grasp of those unarticulated steps, which help provide a fuller understanding of the problem's condition and contexts, they are less able to generalize from a worked example to a new problem. Likewise, in the second study, the authors suggested again that textbooks leave gaps in their explanations, requiring the contribution of the learner: “Any expository passage leaves a great deal of room for readers to provide their own inferences to bridge the gaps in the information provided. Hence, self-explaining seems to be a necessary activity in order to maximize what is learned from any expository passage” (Chi, DeLeeuw, Chiu, and LaVancher 1984, p. 445). The first study referred to the power of self-explanation in helping students develop unstated inference rules; here they seem to speak more generally about the kinds of inferences we must make on first exposure to any new knowledge domain. This explanation seems analogous to the theory of reader-response criticism in literary studies, which has long argued that reading any complex sentence entails a continuous process of filling gaps, making inferences, and supplying relevant context. Chi et al.'s theories are making a similar claim for exposure to new knowledge more generally, whether that takes the form of reading or learning to solve problems. The important takeaway from both studies is that self-explanation can prove to be a vital tool in helping learners fill gaps and make inferences in learning-productive ways.

A second explanation for the power of self-explanation is that it helps learners modify and improve their existing perceptions or knowledge of a subject matter. One of Chi's most recent contributions to the literature is a co-authored survey of much of the research that has been conducted thus far on self-explanation in education. As that article explained, “Learners can come in [to a class or new discipline] with their own ideas, or their own mental models of a concept. These mental models are typically flawed. When a learner encounters instructional material that conflicts with their existing mental models, self-explaining helps repair and revise their understanding” (Chiu and Chi 2014, p. 92). As Chapter 4 noted, some fascinating research in physics has demonstrated how learners can sometimes hold contradictory concepts in a field without ever recognizing or fixing their understanding. It may be that the gap between their existing knowledge and what they learn is too wide and that they can't see their way from one side to the other. Effective self-explanation prompts can provide the tools that help students recognize the problems with their current understanding and point them to the principles or steps that will lead them to new understanding. Ultimately, for both of these explanations for the learning power of self-explanation, it seems clear that monitoring comprehension plays a key role. Self-explanation helps learners recognize problems in their understanding—whether those problems are gaps in their knowledge or mistaken theories or ideas—and prompts them to take productive steps forward in their thinking.

MODELS

Much of the research that presents methods for improving student learning through self-explanation focuses on training students to self-explain during their study behaviors. This seems to me like a valuable approach to recommend to students or implement in tutoring or supervised study sessions, but consider these models for incorporating self-explanation into your courses through small teaching activities.

Select the Principle

Remember that one of the studies supporting the power of self-explanation involved learners selecting a principle from a drop-down menu before solving a problem (Atkinson, Renkl, and Merrill 2003). Those of you who teach in science, technology, engineering, and mathematics (STEM) disciplines and assign homework problems online or teach online might use this study as an incentive to create or seek out learning management systems or programs that enable or require students to pause at key points during their problem-solving sessions and identify the underlying principle that will guide their next step. This strategy might work because the continuous pausing to reflect on principles while solving a problem could eventually create a mental habit that prompts students to engage in such reflection whenever they are faced with the challenge of solving a problem. The other learning strategy tested in that same study was something called *backward fading*, in which students were simply observing or reviewing in the first worked-out examples they encountered; in the next set of examples, they had to complete one or two steps on their own; in the next set, they completed still more of the steps; and so on until they were completing the problem on their own. The researchers found that self-explanation combined with backward fading produced especially robust learning, so it might be the case that self-explanation prompts prove most strong for new learners and that they become less important as learners develop the habit of stopping to reflect on principles on their own and don't require the prompts anymore. In this case, as with many of the techniques discussed in this book, the small teaching strategy of prompting students to select the principle they are using to solve problems online will likely offer the strongest benefit to new learners in a field and to lower performing students more generally.

One important caveat here is that this article notes a previous study in which learners had to *generate* the principles rather than *selecting* them, and in that study self-explanation did not improve learning. The researchers in the current study theorize that the learners in that previous study had too many demands made on their working memory in the tasks they were assigned (giving the self-explanation in that earlier study required the learner to complete several steps on the computer). The more simple opportunity to view several choices and select the correct principle from a drop-down menu made less demands on their working memory, enabling them to concentrate on the problem while still prompting them to tie their cognitive activity with a principle they had learned. So it may be that your first efforts with small teaching forms of self-explanation should begin with pointing students to possible principles and asking them to choose. This seems like an easy tweak that can be made to any virtual learning environment featuring problem solving, but it could just as easily appear in a face-to-face environment in which students are solving problems. Say you are giving your students 10 minutes at the end of a class to solve a type of math problem that you have demonstrated in class that day. As they begin their work, write down three or four possible theorems or principles on the board, and ask them to note in the margin of their paper, as they complete their work, where the relevant principles on the board came into play while they were completing their solutions. For online or traditional homework, make sure they can see the possible principles at the top of the page, and require them, in the same way, to note the application of relevant principles at key junctures along the way. However you need to adapt it to your specific course, the small teaching strategy here entails requiring students who are solving problems to consider a list of possible principles that will guide their work and occasionally to pause and identify the principle that will determine their next step.

Why Are You Doing That?

Most of the work on self-explanation has been conducted on helping students develop their problem-solving abilities, which means most of the research had been conducted in STEM disciplines since they typically assess understanding through the use of problems. The recommendation I am about to make represents an effort to apply the principle of self-explanation to other kinds of disciplines, but you should note that it does not enjoy the more specific support from the learning research that self-explanation in STEM disciplines does. Nevertheless, the work we ask students to complete in writing papers, preparing presentations, and creating other kinds of large-scale assignments could be considered a form of problem solving or at least as a process analogous to problem solving. If we think about these tasks in that way, then self-explanation could play a helpful role here as well. There are lots of good reasons to ask students to break down larger projects like papers and presentations into smaller chunks and complete them over several weeks, one of which is that it helps students stay on task. As I argued elsewhere, it can also help ensure that students do not engage in academic dishonesty by allowing you to get glimpses of their work as it proceeds, thereby preventing them from purchasing some work wholesale and skipping required steps along the way (Lang 2013).

As we saw in the previous chapter, giving students brief periods of time in class to practice the skills they will need for their papers or projects constitutes one highly recommended small teaching strategy. The possibility of students learning from self-explanation offers another excellent reason to parcel out the tasks of larger projects like papers or presentations. Assume your students have a paper due in 3 weeks that requires them to make use of four or five specific writing or analytic skills you have worked on in class. You might allow the final 10–15 minutes of one class per week for students to do some drafting of those essays, informed by the lessons of that specific class period and focused on a specific step in the paper-writing process. One such brief session might be reserved, for example, for drafting an opening paragraph designed to grab the attention of the reader and entice her to keep reading. While the students complete this work, you can walk around and prompt individual students with some form of a very simple question: "Why are you doing that?" In other words, what introduction-writing principle are you using here? Playing on the reader's emotions? Surprising the reader with a shocking statistic? Seeking to find common ground with the reader? Asking the student to pause and articulate the reason for her writing choices should help tap into the learning power of self-explanation. As she explains her choices, she might recognize how to improve what she is doing—just as my daughter learned to correct her driving simply by explaining aloud what she was doing on the road. This general approach—pausing students who are working and prompting them to explain the principle or reason for a choice they are making—could help any time students are working in class, but it seems to me like it would be particularly helpful when students are moving toward paper or project assignments. I know from my own experience teaching writing that students need frequent reminders to apply the principles that we have observed in other writers to their own compositions; in-class writing sessions provide me with a great opportunity to push them back to the principles and deploy them in their writing. So the simple small teaching strategy here consists of pausing working students now and again to ask them to explain what they are doing.

You could just as easily require this of students who are completing projects online. For example, say you are asking students to put together a presentation for an online course you are teaching. Assume as well that you have taught them a few things about how to give presentations, such as how to combine text and graphics in ways that are visually appealing or how to ensure that slides are not overly busy with text or are clearly organized. Instead of simply asking the students to turn in the final presentation, ask them to select any three slides and write an explanation for their design choice in the notes section of those slides. What strategy for creating effective presentations did you use, you might ask them, in constructing and organizing these specific slides? Again, the hope here would be that the students who have to articulate their design strategy for three slides will learn to think about and apply that design strategy to all of the slides they are creating.

Peer Instruction

The use of peer instruction, a teaching strategy made famous by Harvard physicist Eric Mazur, offers a great opportunity to incorporate small teaching self-explanations into a class, especially larger lecture-style courses. More than 20 years ago, Mazur helped develop clickers as a teaching technology to support the process of students learning from one another in his courses. What he labeled as peer instruction process can take a variety of forms, but the basic model looks like this (Schell 2012):

1. The instructor poses or projects on the classroom screen a question that requires thinking or problem-solving skills.
2. The students take a minute or two to attempt to solve the problem or answer the question on their own and to record their answer with their clickers or other personal response system

technology (even colored index cards will work for this purpose). Answers are immediately visible to the instructor.

3. The students then are asked to take a few minutes to turn to a neighbor and justify or explain their answer.
4. The students then resubmit their answers, which again are immediately visible to the instructor.
5. The instructor asks a few students to provide their explanations for their answers and provides the correct answer.

After this final step, the instructor has a variety of options available to her. If most of the students answered the question correctly the second time and the explanations elicited from a handful of students seem to be on target, she can move forward to the next course topic. If, however, the answers from the class are mostly incorrect or the student explanations seem confused, she can pause and revisit the topic that has been under review and then undertake the process again. Derek Bruff's *Teaching with Classroom Response Systems* offers an excellent guide for instructors interested in exploring this teaching format in greater depth (Bruff 2009).

I know that some instructors who use clickers only follow the first three steps, which is absolutely fine. Even by posing questions in the middle of a class, soliciting the answers of every student, and then gauging new instruction accordingly you are injecting an element of active learning into the class that surely has some value. This obviously does not count as peer instruction, though, since no peer instruction happens in that model. If you want to add the learning benefits of self-explanation to your clicker classes and truly engage in peer instruction, you have to incorporate that key fourth step. In a brief video that was made about Mazur's use of this teaching method, which you can find online at the *Turn to Your Neighbor* peer instruction blog from Mazur's research group, the camera holds for a few moments on a group of students who are engaged in that fourth step. One of the students offers her answer to the question, and a student with a puzzled look on his face says in response: "How do you know that?" (Schell 2012). The student who must respond to that question has to engage in a form of self-explanation—and hence should benefit from the positive learning effect that has been described in this chapter. It would be a simple enough effort to enhance learning from self-explanation during peer instruction by always nudging students to refer to the principles that guided their responses when they are explaining their answers to their peers. In some cases, as with the previously described computer-aided self-explanation prompts, you might even show a list of possible principles on the projector screen after the students have made their first answer and prompt them to select which principles led them to that first answer—and which one now seems correct to them.

Think Aloud

Theorists in nursing education have written about an approach to helping students develop clinical reasoning skills that strikes me as offering similar benefits to the peer instruction techniques Mazur developed (Banning 2004). The think-aloud technique of working with nursing students asks them simply to speak out their reasoning as they are attempting to make clinical diagnoses—a consummate form of self-explanation. One overview of the think-aloud approach in nursing education describes its benefits in ways that parallel the benefits of peer instruction. In the same way that the teacher in a peer instruction session gains access to the thought processes of his students, so the think-aloud approach can "provide insights into the types of question(s) that are asked, the train of thought, the ability to make connections and form bridges between core concepts and peripheral subjects, the use of prior knowledge and experiential learning to problem solve and the assessment of the challenges and difficulties encountered during reasoning" (Banning 2004, p. 10). Nursing students who are thinking aloud in class or on rounds can benefit not only from the consequent suggestions or corrections of the instructor but also from their fellow students—another shared feature with peer instruction. Instructors who teach in fields in which students are frequently working individually on developing specific skills (e.g., performing arts, mechanics of various kinds) can layer self-explanation on to the work of their students at any time, as can teachers who are having students doing in-class experiments or laboratory work. Institute a schedule of regular small opportunities for students to pause and self-explain while they work. Consider the think-aloud as another potential way to frame the activity of asking students to explain their reasoning, problem solving, or other cognitive work to each other or to you to help them both connect to principles and allow you both to better understand where they still need help.

Finally, you might consider students who visit you in office hours as ripe candidates for self-explanatory learning. When a student wants help with a paper or project or concept in your office hours, keep this research in mind and prompt the students to self-explain as much as possible, rather than simply reviewing the correct answers or strategies for them.

PRINCIPLES

Self-explanation is one of the least studied teaching activities covered in this book, which gives you more room to experiment but also more opportunities to wander away from what has been clearly established in the research. Keep these three principles in mind as you reflect on how or whether self-explanation belongs in your classroom.

Scaffold Self-Explanation Self-explanation is a complex cognitive activity in its own right, one in which the learner must engage while doing something else. Some research on self-explanation has demonstrated little or no gains in learning, and one theory about those experiments has been that the self-explanation requirement can actually interfere with early-stage learning. So consider how you can scaffold self-explanation requirements to account for this. Initially you might offer students simple choices in selecting possible principles to apply in their work; as they become more skilled, you might ask them to generate their own self-explanations. Don't overtax those working memories.

Point to Principles Although a variety of possible explanations for the power of self-explanations exist, some of which have been referenced already, the most convincing one to me is that self-explanations in problem solving help students connect theory with practice, or principles with concrete steps, or knowledge with doing. But just as we saw with the theory of connections, which the instructor can facilitate but the student must ultimately make, you can provide lots of examples of how principles appear in practice but ultimately the students have to draw these two components together themselves. Consider, then, how you can create opportunities for self-explanation that require students to select or articulate principles as they are making choices, searching for solutions, or revising their work.

Utilize Peer Power Envisioning how to solicit self-explanations from a class of 20 students, much less a class of 200, can be a daunting task. So don't neglect the fact that the room (whether real or virtual) contains lots of other potential listeners for student self-explanations. Whether you use the formal peer instruction process developed by Eric Mazur, the think-aloud approach of nursing education, or some other approach of your own devising, consider whether some student self-explanations can be directed at peers as well as for your benefit. At times it might be more helpful for students to offer their self-explanations to another novice learner, who can better understand their difficulties, than it would be for them to articulate them to you. Remember, though, that self-explanations will be most helpful when the learners receive feedback on their work—so you still might follow up peer activities with a large-group session in which you solicit some explanations and can provide a response.

SMALL TEACHING QUICK TIPS: SELF-EXPLAINING

Self-explanations can happen when students are doing cognitive work of any kind, and offer an excellent route to the kind of mindful learning described in the last chapter. Put in practice in the office, in the classroom, and on the course website.

- For online homework or readings, create spaces for students to self-explain while they work; for newer learners in a field, use drop-down menus that require them to select principles or theories rather than asking them to generate them on their own.
- When students are solving problems at the board, doing laboratory work, or preparing performances, create a regular schedule of opportunities or requirements for them to self-explain their process.
- Use peer instruction with personal response systems and three key steps: students provide an answer, pause and explain it to their neighbors, and then revise their answers.
- Allow class time for students to practice the skills they will need to succeed in assessed activities (as outlined in the previous chapter), and circulate and prompt self-explanations individually while they work.
- In all forms of self-explanation prompts, push students to tie their knowledge of information, principles, theories, and formulae to the specific task they are completing.

CONCLUSION

In that recent summary article surveying the research on self-explanation, Chiu and Chi (2014) pointed out that the research on which types of learners benefit most from self-explanation has yielded decidedly mixed results:

> Self-explanation has been found to be beneficial for low-knowledge students…or students with no prior knowledge of the subject…Some researchers suggest that there may be a greater benefit of self-explanations with more knowledge to draw upon…Many studies find self-explanation beneficial regardless of prior knowledge…The lack of a clear trend in these studies indicates that self-explanations can benefit students with different abilities in different ways. (p. 95)

As the research on self-explanation continues to evolve, undoubtedly underlying principles or nuances will emerge that account for the differences in these findings, and help provide more specific suggestions for effective implementation. But don't let the lack of perfect evidence here become the enemy of the good.

As Chiu and Chi also discussed, the real benefit of self-explanation is that it provides another opportunity for instructors to foster active engagement in their students: "Self-explaining is a constructive activity requiring students to actively engage in their learning process. Active participation is better than passive participation for learning" (p. 92). The same could be said for every technique described in this book: all of them represent different avenues toward active engagement, but none of them should constitute your sole route to that active engagement. Think about self-explanation as the strategy that can prove especially helpful to your students as they are in the early and middle stages of mastering cognitive skills, from solving problems to writing papers, and as a possible spur to better self-understanding for any type of learner. Even small opportunities for students to self-explain, when they are embarked on their learning journey, can help steer them away from misunderstandings and back into the middle of the road.