any conversation about effective teaching must begin with a consideration of how that learning works and how to best apply these principles to new courses. This book is a must-read for every instructor, new or experienced. Although I have been in applied the science of learning to college teaching, and they graciously share it with you in this organized and readable book.”

In this volume, the authors introduce seven powerful learning principles. Full of general principles of learning, distilled from research in psychology; educational research; anthropology; demographics; and organizational behavior) to identify a set of key principles drawn on research from a breadth of perspectives (cognitive, developmental, and social psychology; educational research; anthropology; and organizational psychology; demographics; and organizational behavior). These principles provide instructors with an understanding of student learning that can be used to identify a set of key principles for designing and implementing meaningful educational experiences. The center’s work is based on the idea that combining the science of teaching empowers graduate students and to collaborate with college faculty to create the conditions for students to learn and, through this, transform their world.

HOW LEARNING WORKS
7 Research-Based Principles for Smart Teaching

Susan A. Ambrose
Michael W. Bridges | Michele DiPietro
Marsha C. Lovett | Marie K. Norman

FOREWORD BY RICHARD E. MAYER
How Learning Works
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How Learning Works
CHAPTER 5
What Kinds of Practice and Feedback Enhance Learning?

When Practice Does Not Make Perfect ...
I teach a public policy course to juniors, and I believe strong communication skills are essential to moving up the ranks in the public sector. As a result, I require my students to write frequently. The three papers I assign focus on the different types of writing my students will potentially do: a policy briefing, a persuasive memo to their boss, and an editorial for a newspaper. I had expected the students’ writing on these assignments to be at least decent because all of our students are required to take two writing courses in their first year. Then, when I saw the serious problems in their first papers, I thought at least I could help them improve. So I have been spending an enormous amount of time grading and writing margin comments throughout their papers, but it does not seem to be doing any good: the second and third assignments are just as bad as the first. As much as I think these assignments are useful because they prepare students for their future professional lives, I am ready to nix them because the students’ writing is so poor and my efforts are bringing about little or no improvement.

Professor Norman Cox
They Just Do Not Listen!
Last semester, when I taught Medical Anthropology, the students’ research presentations were all glitz and very little substance. So this time, because this project is worth 50 percent of their final grade, I tried to forewarn my students: “Do not be seduced by technology; focus on substantive anthropological arguments and create engaging presentations.” And yet, it happened again. Last Tuesday, student after student got up in front of the class with what they believed to be engaging presentations—fancy fonts in their PowerPoint slides, lots of pictures swishing on and off the screen, embedded video clips, and so on. It was clear they had spent hours perfecting the visuals. Unfortunately, although their presentations were visually stunning, the content was very weak. Some of the students had not done thorough research, and those who did tended merely to describe their findings rather than craft an argument. In other cases, students’ arguments were not supported by sufficient evidence, and most of the images they included were not even connected to the research findings. I thought I was clear in telling them what I wanted and did not want. What is it going to take to make them listen?

Professor Tanya Strait

WHAT IS GOING ON IN THESE STORIES?
In both stories, the professors and their students seem to be putting in time and effort without reaping much benefit. For example, Professor Cox makes lengthy comments on his students’ writing but fails to see any improvement across assignments. Professor Strait’s students spend an inordinate amount of time on aspects of the presentation that actually matter least to her,
What Kinds of Practice and Feedback Enhance Learning?

despite the guidance she gave them. And both professors are understandably frustrated that students’ learning and performance is not up to expectations. A theme running through both stories is that time is being misspent—just the kind of mistake that neither students nor instructors can afford to make.

In the first story, Professor Cox’s students probably enter his course with only basic writing skills. Unfortunately, even though the students may begin to develop additional writing skills through the practice they get during the first writing assignment, these new skills are not built upon through the later assignments. Recall that Professor Cox’s assignments involve different genres (policy briefing, memo, and editorial). This means they involve somewhat different writing skills to address the distinct goals, audiences, and writing styles specific to each (see Chapter Four). Moreover, even though Professor Cox gives plenty of comments on his students’ papers, the students probably have little opportunity to incorporate this feedback into further practice because each subsequent assignment is so different from the previous ones.

In the second story, Professor Strait tells her students that their arguments should have substance and their presentations should be engaging. However, her students seem not to understand what constitutes a substantive anthropological argument based on thorough research or what characteristics she identifies with engaging presentations. Although it is true that Professor Strait’s students have spent the bulk of the semester reading and analyzing anthropological arguments, they have had relatively little opportunity to conduct library research and construct arguments of their own. So this partly explains their disconnect. Similarly, although these students have accumulated a good deal of prior experience giving oral presentations, they have not done so earlier in her course, so they mistakenly equate putting glitz in their presentations with what Professor Strait wants. Thus, the students probably have only minimal skill at argument
construction and yet great familiarity with applying technical skills to prepare PowerPoint slides (for example, adding animations, pictures, and sound). Thus, it appears that these students are falling back on the more comfortable task of working on visuals at the expense of articulating an argument in their presentations. Professor Strait reasonably assumes that her warnings should be sufficient to guide students, but students often need significantly more guidance and structure than we would expect in order to direct their efforts productively. With only one chance to “get it right” with regard to this large-scale project, these students end up losing a key learning opportunity.

WHAT PRINCIPLE OF LEARNING IS AT WORK HERE?

We all know that practice and feedback are essential for learning. Unfortunately, the biggest constraint in providing sufficient practice and feedback to students is the time it takes—both on the part of students and faculty. Although we cannot control the length of a semester or class period, we can be more efficient in designing practice opportunities and giving feedback. Thus, this chapter focuses on ways to “work smarter” by exploring what kinds of practice and feedback are most productive.

It is important to acknowledge that all practice is not equal. In particular, there are more and less effective ways students can practice. Consider two music students who spend the same amount of time practicing a piece after having made several errors in a difficult passage. If one of the students practices for an hour, spending the majority of that time working on the difficult passage and then playing that passage in the context of the whole piece, this student will be likely to show sizeable performance gains. However, if the other student spends the same hour but
uses that time to play through the whole piece a few times, much of that time will be spent suboptimally by practicing parts of the piece that were already mastered. This is reminiscent of Professor Strait’s students, who seem to spend much of their time on what they already know—how to make fancy PowerPoint slides—only to miss their main chance at practicing less developed skills. In other words, how students spend their time on a learning activity (either in or out of class) determines the benefits they gain.

This problem of unproductive practice is even worse when students fail to receive sufficient feedback along the way. Think about the first music student who spent considerable time on the problematic passage rather than playing the whole piece multiple times. Even though this student’s approach had greater potential to fix all the errors, this student could have introduced new errors without realizing it because no feedback was provided. In this way, lacking feedback, the first student’s practice actually could have entrenched new, bad habits. This example highlights the critical role that feedback plays in keeping learners’ practice moving toward improvement. In other words, students need both productive practice and effective feedback.

**Principle:** Goal-directed practice coupled with targeted feedback are critical to learning.

At one level, this principle states the obvious: practice is important, and feedback is helpful to learning. To be clear about terminology, we define “practice” as any activity in which students engage their knowledge or skills (for example, creating an argument, solving a problem, or writing a paper). We define “feedback” as information given to students about their performance that guides future behavior. However, the full potential of practice and
feedback is not realized unless the two are effectively combined. For example, Professor Cox provides an enormous amount of feedback, but it is not coordinated with practice opportunities in which students could incorporate the feedback and refine a repeated set of skills. In contrast, when practice and feedback are focused on the same aspects of students’ performance, students have the chance to practice and refine a consistent body of new knowledge and skill. Figure 5.1 depicts this interaction as a cycle: practice produces observed performance that, in turn, allows for

Figure 5.1. Cycle of Practice and Feedback
targeted feedback, and then the feedback guides further practice. This cycle is embedded within the context of learning goals that ideally influence each aspect of the cycle. For example, goals can direct the nature of focused practice, provide the basis for evaluating observed performance, and shape the targeted feedback that guides students’ future efforts.

Although practice and feedback ideally go hand in hand—as this chapter’s principle and Figure 5.1 indicate—each has a sizeable body of literature. So we discuss the research in two major sections below—one on practice and the other on feedback—and highlight the importance of their coordination.

WHAT DOES THE RESEARCH TELL US ABOUT PRACTICE?

Research has shown that learning and performance are best fostered when students engage in practice that (a) focuses on a specific goal or criterion for performance, (b) targets an appropriate level of challenge relative to students’ current performance, and (c) is of sufficient quantity and frequency to meet the performance criteria. The following sections focus on these three characteristics of practice.

**Focusing Practice on a Specific Goal or Criterion**

Research shows that the amount of time someone spends in *deliberate practice* is what predicts continued learning in a given field, rather than time spent in more generic practice (Ericsson, Krampe, & Tescher-Romer, 2003). One of the key features of deliberate practice is that it involves working toward specific goals. As an illustration of the power of such goal-oriented practice, research shows that world-class musicians spend much of their time
engaging in rather demanding practice activities, continually monitoring their performance toward a particular goal, and then, once it is achieved, pushing themselves to strive for a new goal (Ericsson & Lehmann, 1996; Ericsson & Charness, 1994). In contrast, we all know of people who have studied a musical instrument—even spending considerable time practicing it—but who do not achieve a very high level of performance. Ericsson’s explanation of these contrasting paths is that those who spend their considerable practice time working deliberately toward a specific goal tend to go on to be expert musicians, whereas those who do not engage in such deliberate practice do not.

Intuitively, it makes sense that having specific goals for practice would be helpful to learning. Goals provide students with a focus for their learning, which leads to more time and energy going to that area of focus. Consistent with this, Rothkopf and Billington (1979) found that students who had specific goals when they were learning from a text paid more attention to passages that were relevant to their goals and hence learned those passages better. Another advantage of having a goal to direct one’s learning is that one can monitor (and hence adjust) one’s progress toward that goal along the way (see Chapter Seven).

A key challenge in providing goal-directed practice is that instructors often think they are conveying specific goals to students when, in fact, they are not. This is natural because, as experts, we often see things very differently from our students (see Chapter Four), and so we tend not to recognize when our stated goals are unclear to students or when students are likely to misinterpret our criteria. A case in point is Professor Strait, who thought she was being clear by advising her students to focus on “substantive anthropological arguments” and “engaging presentations”—two ideas that carried specific meaning in her field of expertise. However, her students did not share that expertise, so they did not
share her sense of the specific goals for their work. Without a clear idea of what Professor Strait wanted, the students “filled in the blanks” based on their prior experience (see Chapter One). Unfortunately, in this case, students’ interpretations of the goals led them to spend their time in a way that gave more practice to skills they already had developed (such as creating glitzy PowerPoint presentations) and less practice to skills they needed to develop (such as creating anthropological arguments).

When instructors do not clearly articulate their goals, it is difficult for students to know what (or how) to practice. For example, giving students the goal of “understanding a key concept” tells rather little about the nature or level of understanding students should be trying to attain. In contrast, the goals of “recognizing when a key concept is at issue” or “explaining the key concept to a particular audience” or “applying the key concept to solve problems” are more concrete and directive. Note that these more specifically stated goals share several key features. First, they all are stated in terms of something students do, which automatically leads to more concrete specifications that students can more easily interpret correctly. Second, all of these goals are stated in such a way that students’ performance can be monitored and measured (by instructors as well as students themselves), which enables the provision of feedback to help students refine their performance or learning. For more information on articulating effective learning goals (also called learning outcomes or objectives), see Appendix D.

The notion of articulating goals in a measurable way still leaves open the question (to students and instructors) of how much of a particular measurable quality is enough for the goal to be achieved. Research has shown that clearly specified performance criteria can help direct students’ practice and ultimately their learning. For example, Goodrich Andrade (2001) found that creating a rubric (a clear description of the characteristics associated
with different levels of performance; see Appendix C) and sharing it with students when an assignment is distributed leads to better outcomes—both in terms of the quality of work produced and students’ knowledge of the qualities associated with good work.

An important caveat here, however, is that the goals one specifies must be in accord with what one really wants students to learn. For example, Nelson (1990) studied a case in which students were given detailed specifications for a research paper, such as the requirement to include at least three pieces of evidence supporting their argument. In writing their papers, students took this and other similar prescriptions to heart and included the required pieces of evidence in their writing. An important missing piece, however, was that the paper assignment did not specify higher-level goals such as having a well-organized paper or making a coherent argument. Thus, although these students included the required pieces of evidence in their papers, they tended to fall short on other important criteria. A key implication of this work is that explicitly communicating goals for students’ performance can indeed guide their work, but one must be sure that those goals are ones that will support students in what they need to do and learn.

**Identifying the Appropriate Level of Challenge for Practice**

Specifying goals and criteria is not enough. To ensure that students’ practice has a significant effect on learning, the practice they do should be at an appropriate level of challenge and, as necessary, accompanied by the appropriate amount and type of support. An appropriate level of challenge is neither too hard (the student struggles, makes many errors, and possibly gives up) nor too easy (the student completes the goal without much effort and
What Kinds of Practice and Feedback Enhance Learning?

**Strategies Addressing the Need for Goal-Directed Practice**

**Conduct a Prior Knowledge Assessment to Target an Appropriate Challenge Level**  Students come into our classes with a broad range of pre-existing knowledge, skills, and competencies. Giving a prior knowledge assessment (such as a survey, pretest, or early ungraded assignment) can help you gauge students’ strengths and weaknesses in order to better target their practice at the right level (based on where they are, not where you wish they were). A performance assessment (for example, actual problems to solve or terms to define) will provide the best indication of what students actually know or can do, while a survey asking them about the level of their knowledge (for example, can they define or apply, do they know when to use) will give you a sense of what students believe they know or can do. (See Chapter One for additional, related strategies and Appendix A for more information on incorporating student self-assessments.)

**Be More Explicit About Your Goals in Your Course Materials**  Without specific goals for the course as a whole or for individual assignments, students often rely on their assumptions to decide how they should spend their time. This makes it all the more important to articulate your goals clearly (in your course syllabus and with each specific assignment), so students know what your expectations are and can use them to guide their practice. Students are more likely to use the goals to guide their practice when the goals are stated in terms of what students should be able to do at the end of an assignment or the course. (See Appendix D for more information on articulating learning goals.)
Use a Rubric to Specify and Communicate Performance Criteria  When students do not know what the performance criteria are, it is difficult for them to practice appropriately and to monitor their progress and understanding. A common approach to communicating performance criteria is through a rubric—a scoring tool that explicitly represents the performance expectations for a given assignment. A rubric divides the assigned work into component parts and provides clear descriptions of the characteristics of high-, medium-, and low-quality work associated with each component. (See Appendix C for more information on rubrics.)

Build in Multiple Opportunities for Practice  Because learning accumulates gradually with practice, multiple assignments of shorter length or smaller scope tend to result in more learning than a single assignment of great length or large scope. With the former, students get more opportunity to practice skills and can refine their approach from assignment to assignment based on feedback they receive. For example, this strategy can free you to think beyond the traditional term paper and be more creative in the variety and number of shorter writing assignments you require (for example, a letter, program notes, or a short policy memo). Bear in mind, however, that a single opportunity to practice a given kind of assignment is likely to be insufficient for students to develop the relevant set of skills, let alone to be able to incorporate your feedback on subsequent, related assignments.

Build Scaffolding into Assignments  In order to adjust a task so that it continues to target an appropriate level of challenge for students, provide scaffolding. Scaffolding refers to the process by which instructors give students instructional supports early in their learning, and then gradually remove these supports as students develop greater mastery and sophistication. One way to
apply scaffolding to a more complex assignment is to ask students to first practice working on discrete phases of the task and, later, ask students to practice integrating them. (See Chapter Four.)

**Set Expectations About Practice** Students can underestimate the amount of time an assignment requires. As a result, it is vital to provide students with guidelines for the amount, type, and level of practice required to master the knowledge or skills at the level you expect. There are at least two ways to help you estimate the time students will need. Some faculty members collect data by asking students, over a number of semesters, how long an assignment took to complete. They can then report to their current students the average and range of time spent by past students. Other faculty members adhere to a general rule of thumb that it takes students approximately three to four times as long as it would take them to complete an assignment. This ratio may vary from situation to situation, however, so it is worthwhile to try multiple strategies for this estimation and to adjust based on one’s experience, as necessary.

**Give Examples or Models of Target Performance** Building on the previous strategy, it can also be helpful to show students examples of what the target performance looks like (such as a model design, an effective paper, or a robust solution to a problem). Sharing samples of past student work can help students see how your performance criteria can be put into practice in an actual assignment. Such examples are even more powerful when you either highlight or annotate for students particular features of the sample assignment that “work.”

**Show Students What You Do Not Want** In addition to sharing exemplary models of target performance, it can be helpful to contrast those with examples of what you do not want, by illustrating
common misinterpretations students have shown in the past or by explaining why some pieces of work do not meet your assignment goals. For example, in the case of writing or giving presentations, it is often helpful to share samples that are annotated to highlight weak features. Such samples can also be used to give students practice at distinguishing between high- and low-quality work. To get students more actively involved and check their understanding, you can ask students to grade a sample assignment by following a rubric (see Appendix C).

Refine Your Goals and Performance Criteria as the Course Progresses  As students move through a course practicing various skills, you may need to add new challenges, refine your goals to meet students’ continually changing proficiency, or both. For example, once students have acquired competency with a skill, you may want them to be able to apply that skill more quickly, with less effort, or in more diverse contexts. You need to continually articulate the increasingly sophisticated goals you want students to work toward.

Strategies Addressing the Need for Targeted Feedback

Look for Patterns of Errors in Student Work  Within a class, students can often share common errors or misconceptions that only are revealed when you make a concerted effort to look for patterns. For example, you might identify an exam question that many students missed or a homework assignment that was particularly difficult for many students. You may also notice that during your office hours multiple students are asking the same type of question or are making the same kind of mistake. If you are grading student work, you have access to this information and can seek out the patterns of errors. If you have TAs grading, ask
them to summarize any major patterns of errors or misconceptions and report these to you. Once you have identified common patterns across students, you can provide feedback to the class as a whole using the following strategies.

**Prioritize Your Feedback**  The question of exactly what information feedback should include is dependent on many aspects of the course context: your learning objectives (for the course and the particular assignment), level of students, what they most need to improve, and the time you have available. So the key to being efficient while still providing effective feedback is to think carefully about what information will be most useful to students at a particular point in time and to prioritize that information in your feedback. In many cases, it is not necessary or even best to give feedback on all aspects of students’ performance but rather focus your feedback on key aspects of the assignment. One way to do this is to offer feedback on a single dimension at a time (for example, one aspect of presenting an argument, one piece of the design process, or one step in problem solving). This strategy avoids overwhelming students with too much feedback and enables them to engage in targeted practice—that is, with a specific goal in mind.

**Balance Strengths and Weaknesses in Your Feedback** Students are often unaware of the progress they are making, so communicating to them the areas where they are doing well or have improved is just as important as communicating to them the areas where they lack understanding or need further improvement. The positive feedback indicates which aspects of their knowledge and performance should be maintained and built upon, whereas the negative feedback indicates what aspects should be adjusted (and, ideally, how). Moreover, beginning with targeted feedback that is positive can increase students’ sense of efficacy
and hence enhance their motivation. How you balance positive versus negative feedback for a given class or for a particular student should depend on your priorities and their needs.

**Design Frequent Opportunities to Give Feedback**  The prerequisite to giving frequent feedback is to provide multiple opportunities for students to practice using their knowledge and skills. More tasks of shorter length or smaller scope provide the frequency of feedback that allows students to refine their understanding. This also makes a more manageable workload for you and your students. As indicated in other strategies in this section, not all feedback needs to be focused on individual students or come from the instructor. These strategies reduce the load on instructors in giving frequent feedback.

**Provide Feedback at the Group Level**  Not all feedback has to be individual to be valuable. Although you might want to write notes on individual assignments (which takes more time and hence decreases how quickly you can get feedback to students), you might at times identify the most common errors that students committed, provide the group with this list, and discuss those errors. In a similar vein, you can show the group two examples of high-quality performance and discuss the features that make this work “A” level.

**Provide Real-Time Feedback at the Group Level**  In a classroom situation, especially large lectures, instructors often assume that it is impossible to give effective feedback. However, by posing questions to the class in a format that allows easy collection of their responses, instructors can overcome this challenge. You can collect students’ responses quickly in a paper-based way (with color-coded index cards) or with interactive technology (often called personal response systems, or “clickers”). In either case, the
instructor poses a question and students respond (either by raising the index card corresponding to their answer or by submitting their answer choices via clicker). The instructor can then easily glean the proportion of correct/incorrect answers (either by scanning the room for the different colors of index cards or viewing the computer screen that tallies the clicker responses). Based on this information, the instructor can decide how to give appropriate feedback to the class as a whole. For example, the instructor may simply indicate that there was a high proportion of incorrect answers and ask students to discuss the question in small groups before polling them again. Alternatively, the instructor might recognize a common misconception in students’ responses and provide further explanation or examples, depending on the nature of the misconception.

**Incorporate Peer Feedback**  
Not all feedback has to come from you to be valuable. With explicit guidelines, criteria, or a rubric, students can provide constructive feedback on each other’s work. This can also help students become better at identifying the qualities of good work and diagnosing their own problems. Besides the advantages to students, peer feedback allows you to increase the frequency of feedback without increasing your load. Keep in mind, however, that for peer feedback to be effective, you need to clearly explain what it is, the rationale behind it, how students should engage in it, and—as this chapter attests—give students adequate practice with feedback on it for it to reach its potential. (For more information, see Appendix H.)

**Require Students to Specify How They Used Feedback in Subsequent Work**  
Feedback is most valuable when students have the opportunity to reflect on it so they can effectively incorporate it into future practice, performance, or both. Because students often do not see the connection between or among
assignments, projects, exams, and so on, asking students to explicitly note how a piece of feedback impacted their practice or performance helps them see and experience the “complete” learning cycle. For example, some instructors who assign multiple drafts of papers require students to submit with each subsequent draft their commented-on prior draft with a paragraph describing how they incorporated the feedback. An analogous approach could be applied to a project assignment that included multiple milestones.

SUMMARY

In this chapter, we have tried to move beyond simple maxims such as “practice makes perfect” or “the more feedback, the better” in order to hone in on the critical features that make practice and feedback most effective. Key features of effective practice include (a) focusing on a specific goal or criterion for performance, (b) targeting an appropriate level of challenge relative to students’ current performance, and (c) being of sufficient quantity and frequency so students’ skills and knowledge have time to develop. Key features of effective feedback are that it (a) communicates to students where they are relative to the stated goals and what they need to do to improve and (b) provides this information to students when they can make the most use of it. Together, then, practice and feedback can work together such that students are continuing to work toward a focused goal and incorporating feedback received in a way that promotes further development toward the goal. When practice and feedback are carefully designed with all these features in mind, we can prioritize them appropriately and help make the learning-teaching process not only more effective but also more efficient.