

Chapter 2

Retrieving

INTRODUCTION

I wrote almost every word of the first edition of this book sitting in a coffee shop about two blocks from my home. Most weekdays I would walk in, find a spot near an electrical outlet, fire up my laptop, and then head to the counter to order my beverage. I am a person of routines when it comes to food and drink, so every day for about six months I placed the same order: medium green tea. The coffee shop had its routines as well, which meant that most of the time I was placing my order with the same young woman. Yet, in spite of the fact that she saw my smiling face three or four days a week making the same order, she always looked up at me expectantly when I arrived, as if I had not requested the same thing a hundred times before. She would even ask me the same two questions about my tea order every time: “Hot or cold?” “Honey or lemon?” Hot and No. Every time. As the weeks and months of this stretched on, it became a mild source of amusement to me to see if she would ever remember my order. She never did. Until, that is, I walked in one day and felt a little mischievous.

“Can I help you?” she said.

“Can you guess?” I replied.

She looked up as if seeing me for the first time, and she smiled sheepishly.

“Oh gosh,” she said. “Why am I blanking?”

1/1/12

might sometimes take the form of simple memory exercises—after all, we likely all have certain key facts or basic information that we want students to have mastered. For example, I want students in my British literature survey course to know that Robert Burns is Scottish because his Scottish identity helped influence much of what he wrote. They can't do higher order analysis of a Burns poem on a final exam if they forget that key fact. **But rather than asking students to practice remembering his nationality by selecting it from a list, I can ask them short-answer questions that require them to remember that fact and put it to some use: How does the national identity of Robert Burns influence his writing?**

SMALL TEACHING QUICK TIPS: RETRIEVING

Memory retrieval works especially well in brief classroom interventions. You can find room for retrieval in almost any class period or learning session, even if it takes only a minute. But my favorite opportunities for retrieval appear in the opening and closing moments of class, or in the form of regular quizzes or writing exercises.

- Open class periods or online sessions by asking students to remind you of content covered in previous class sessions; allow students time to reflect for a few moments if you do so orally.
- Close class by asking students to write down the most important concept from the homework and the class period and one question or confusion that still remains in their minds.
- Close class by having students take a short quiz or answer written questions about the day's material or solve a problem connected to the day's material.

- Give frequent, low-stakes quizzes (at least weekly) to help your students seal up foundational course content; favor short answers or problem solving whenever possible so that students must process or use what they are retrieving.
- Use your syllabus to redirect students to previous course content through quizzes or oral questions and discussion.

CONCLUSION

I have heard college and university professors express reluctance at the use of regular quizzing because they feel like it infantilizes the students or changes the atmosphere of the classroom from one of shared learning and discussion to one of testing and evaluation. I had those exact same feelings about quizzing when I began my teaching career. I just wanted to engage in interesting discussions with my students about literature and not impede our relationship with heavy-handed tactics like quizzing and testing.

However, I had too many experiences of having interesting discussions about literature with students who had not done the reading (but who were very good at faking their way through discussions) and who remembered nothing of what we had discussed at the end of the semester for that perspective to last very long. So I understand any emotional hesitation you might feel at the prospect of regular retrieval practice in your classroom, but remember that such practice helps your students learn foundational knowledge as effectively as anything else we know. Think about retrieval practice as I have been arguing for it here: as an activity that lends itself perfectly to small teaching and therefore doesn't require you to devote huge amounts of time or energy to it.

If you consider it in that light and push yourself to implement regular quizzing or retrieval practice, you will likely find that your students are grateful for it by the end of the semester. In

“It’s OK,” I said. “No problem. Medium green tea. Hot, nothing in it.”

The next time I showed up at the coffee shop was a couple of days later. I walked in, found my spot, fired up the laptop, and approached my forgetful friend at the counter. To my astonishment, she pointed at me with a smile and said:

“Medium green tea, hot, no honey or lemon?”

This little story illustrates perfectly a learning phenomenon called the retrieval effect (and sometimes also called the testing effect). Put as simply as possible, the retrieval effect means that if you want to retrieve knowledge from your memory, you have to practice retrieving knowledge from your memory.



The more times that you practice remembering something, the more capable you become of remembering that thing in the future. Every time I walked into that coffee shop and told the barista my order, she was passively receiving that information from me; she did not have to draw it from her memory. She was doing the student equivalent of staring at her notes over and over again—a practice that cognitive psychologists will tell you is just about the most ineffective study strategy students can undertake (Weinstein and Sumeracki 2019, pp. 23–25). When I made one very small change to our interaction by “testing” her to remember my order—even though she didn’t get it right—she had to practice, for the first time, drawing that piece of information from her memory. And because it was such a simple piece of information, one practice was enough to help her remember it for the next time. It won’t be quite as simple for our students, who have to remember more complex stuff than my order at the coffee shop. But the principle is exactly the same. The more times any of us practice remembering something we are trying to learn, ~~the more firmly we lodge~~ it in our memories for the long term.

The retrieval effect is also sometimes called the testing effect as a way to help teachers recognize its significance for student learning in their classrooms. Teachers (and students

and parents) typically think about tests as a means to measure student learning. But tests, thought about in the most general way possible, are actually memory exercises. And if the research suggests that memory exercises improve our memories, that should mean that tests have the potential not just to measure learning but also actually to improve it. The problem with using the phrase *the testing effect* is that many of us have a very limited understanding of what the word *test* means—it recalls for us anxious students biting their pencil erasers as they sweat their way through a multiple-choice final exam. But, of course, testing can happen in a thousand different ways, from small daily quizzing exercises to oral examinations to online short-answer questions. The research that we will consider in this chapter encompasses multiple types of these testing activities, all of which help students exercise their memory muscles to improve and solidify their knowledge base. Testing, here, simply means forcing learners to recall learned information, concepts, or skills from their memory. It can take the form of oral questioning in the first five minutes of class just as easily as it can take the form of a high-stakes final exam. For that reason, I will continue to speak primarily of the retrieval effect and retrieval practice in what follows to avoid limiting your thinking about how you might manifest this teaching strategy in your classroom, and especially to help you think about how to implement retrieval practice through a variety of small teaching activities.

IN THEORY

A host of experiments designed to illustrate the power of the retrieval effect have come from the Memory Lab of Henry L. Roediger at Washington University in St. Louis, which houses multiple researchers exploring the educational implications of

their work on learning, cognition, and memory. As Roediger and his co-authors report in *Make It Stick: The Science of Successful Learning*, in 2006 researchers from the Memory Lab began working with a middle school in Columbia, Missouri, to see whether they could leverage the power of the retrieval effect in order to improve student learning in real classrooms (Brown, Roediger, and McDaniel 2014). Then-research associate Pooja K. Agarwal worked with a sixth-grade social studies teacher, Patrice Bain, to explore whether a structured set of retrieval practice activities in her six classes would help improve her students' learning. Rather than using retrieval practice with some of the classes and not with others, they divided the course material—standard-issue middle-school social studies textbook stuff, covering major world civilizations—into three groupings and treated each of those groupings differently. For the first set of material, the students were given three opportunities to practice retrieval in the form of regular quizzes, which were spaced out in the following way: one at the beginning of class, after they had read course material for homework, but prior to the teacher discussing it; one at the end of class, after discussion of the material; and one just before each major test for the class. The teacher excused herself from the room during the quizzes; the students were shown the correct answers after they had completed the quizzes, but they did not count toward their grades. For the second grouping of material, students had the opportunity to restudy key concepts from the course that would appear on the exams. Bain covered the third grouping of material with her usual teaching methods, without any additional study or retrieval practice. It's worth noting, before discussing the results, that the additional retrieval practice used with the first grouping of material did not come *in addition to* students' normal classroom time. It took place within the regular classroom hours, which means it was substituting for something else—lectures, class discussions, independent study time, or whatever else the teacher did on non-quiz days. This

deserves notice because some teachers might fear that retrieval practice will take time away from other, more important learning activities.

The experiment yielded, for our purposes, three important results. First and foremost, the authors explain, it demonstrated the potency of retrieval practice: “The kids scored a full grade level higher on the material that had been quizzed than on the material that had not been quizzed” (Brown, Roediger, and McDaniel 2014, p. 35). A year later the research group tried this same experiment in eighth-grade science courses at the same school, and the results were even stronger: “At the end of three semesters, the eighth graders averaged 79 percent (C+) on the science material that had not been quizzed, compared to 92 percent (A-) on the material that had been quizzed” (p. 35). Both of these experiments reveal the incredible power of retrieval practice to improve students’ long-term mastery of core knowledge. Course grades on material that was the subject of regular retrieval practice, in the form of standard course quizzing, were at least a full letter higher than course grades on non-quizzed material.

A second important result of the original experiment was that the grades on the second grouping of material (for which the students had been given additional study time) were no better than the grades on the third grouping of the material (which had no special intervention at all). In other words, additional study time provided them with no additional learning benefit. “Mere re-reading,” the authors conclude, “does not much help” (p. 35). Finally, and perhaps most importantly, the positive results of the experiment extended far out in time: “The testing effect persisted eight months later at the end-of-year exams” (p. 35). This has obvious implications for us as teachers; we want students to remember our course material beyond the initial testing period, and spaced-out retrieval practice (more on this spacing in Chapter Three) seems to have a powerful impact on long-term learning. But it’s

worth repeating the main point of these results one last time: a brief (and ungraded) multiple-choice quiz at the beginning and end of class and one additional quiz before the exam raised the grades of the students by a full letter grade.

Let's consider two more demonstrations of the power of retrieval practice, each of which will add some nuance to our understanding of the role it can play in education..

A 2007 experiment by Roediger and Butler helps confirm what many readers might suspect: not all types of testing are equal. In this experiment, Roediger and Butler had students observe three 30-minute lectures on art history, with slideshows, over a 3-day period. At the end of each lecture, students did one of four things: (a) take a short-answer test on the material they had just learned; (b) take a multiple-choice test on the material; (c) restudy some of the key facts from the lecture; or (d) walk out the door with no additional activity (which of course is what happens at the conclusion of most college classes). The students came back 30 days after the last of the three lectures to take a final short-answer test on the material; this time-lapse created what the authors called “a more realistic timescale over which students may retain classroom lecture information prior to a test.” In other words, students often learn material in class and are not tested on it until several weeks later; a final test 30 days after the learning period mimicked that longer interval (p. 517). The students who took the short-answer tests directly after the lectures (group a) scored the highest on the final exam, at 47%; the students who took multiple-choice exams (group b) and had additional study time (group c) scored about equally, at 36%; those who had no activity (group d) scored around 20%. These numbers can seem a little disheartening, but keep in mind that in this experiment students had no reason or opportunity to revisit the course material during the 30-day interval between the lectures and the final exam—which, to a certain extent, makes the results of the students who took the short-answer exam really

astounding, since they recalled almost 50% of the material 30 days later with absolutely no re-exposure or study time.

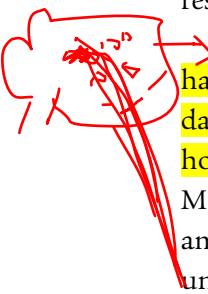
But this study helps us draw out some nuances. First, the students who performed the best were the ones who had to put the most active thought into their answers through short-answer questions. In the pithy formulation of Daniel Willingham, “Memory is the residue of thought” (Willingham 2009, p. 54). Those short-answer questions required students to formulate answers in their own words, and hence to spend more time answering than the multiple-choice questions. Second, note that in this case the students who had the opportunity to engage in what the authors call “focused restudy” did perform better than the students who had no activity at all. So while some experiments have shown little difference between students who had extra study time and students who had no additional study or testing, this one yielded a different, more positive result. Third and finally, the students who scored the highest on the post-30 day test, which was a short-answer test, were the students who had taken previous short-answer tests. This could mean that the similarity in format between the two types of questions produced the better learning results. In other words, it may be that answering multiple-choice questions at the conclusion of a lesson produces one type of learning, and that type of learning does not translate well into performing well on short-answer questions.

To address that possibility, and to make a case for the special power of writing and problem-solving activities as a part of your retrieval practice, I want to consider one final experiment, this one conducted not by memory researchers in the laboratory but by the instructor in a real set of college chemistry courses. Brian Rogerson details in this study the result of an experiment he conducted over five semesters of teaching introductory chemistry at Richard Stockton College in New Jersey. During three of those semesters, which included his first year as a full-time faculty

member, he taught using standard lecture techniques. During two of them, he made only one simple change to the course: 10 minutes before the end of each 75-minute class period, he stopped and asked students to respond to a question on the material he had just covered in the lecture. This question was the chemistry equivalent of a short-answer question, as you can see in this example: “Give two reasons that K is more reactive than Li.” Some of them required answers in the form of equations or formula, but all of them required more than just repetition from memory. The students wrote their answers down twice—once on a form that they returned to him and once on a paper to keep. This allowed Rogerson to review the answers prior to the next class—though he did not grade or return them—and then to address problems in their responses at the beginning of that next class session, with students able to check the answers they had given.

In the three semesters in which he did not conduct these end-of-class assessments (which he derived from Angelo and Cross’s justly famous book *Classroom Assessment Techniques*) the rate of students who failed or withdrew from the course was 35%. In the semesters in which he used the technique, that rate fell to 17%. The number of Cs and Ds rose in the assessment semesters, which means that students who would have dropped were now performing at the C and D levels—not a miraculous transformation, but an impressive one nonetheless. The rates of A and B students stayed roughly stable in both cohorts, which may partially reflect the fact that an A or B student doesn’t have as much room to improve as a C or D student does. Interestingly, in his introduction and discussion of this experiment, Rogerson made no mention of the possibility that retrieval practice may help explain the results of this experiment. Like most instructors who use assessments of any kind, he implemented it as a means to gauge the learning of his students and then saw it as an opportunity to provide feedback on their work. But you will note the similarity between the small task he required

of his students and what the researchers in our last experiment required of their subjects: directly following the lecture, they asked students short questions about the material they had just covered. The results of such questions can be disheartening, as Rogerson pointed out: “Even after classes in which I felt I had explained something very well and thoroughly, there were students for whom the answer to the assessment was not obvious” (Rogerson 2003, p. 163). But even when students are frequently providing wrong answers, as they did for Rogerson and will do in your classes—and as long as you provide them feedback to help them correct their mistakes—the results of these experiments are hard to dismiss.



It remains for us only to understand why the retrieval effect happens. The very short version is that memory researchers these days seem to believe that our long-term memories are capable of holding a huge amount of material. As cognitive psychologist Michelle Miller writes in *Minds Online*, “There’s wide consensus among memory researchers that long-term memory is essentially unlimited” (Miller 2014, p. 94). However, that unlimited storage capacity can be as much of a problem as a long-term memory with smaller storage capacity. In an earlier essay on what college teachers should know about memory, Miller explained that “in long-term memory the limiting factor is not storage capacity, but rather the ability to find what you need when you need it. Long-term memory is rather like having a vast amount of closet space—it is easy to store many items, but it is difficult to retrieve the needed item in a timely fashion” (Miller 2011, p. 119). So the challenge for students, or for any of us, is not jamming facts and information down into our long-term memories but instead drawing those facts and information out when we need them or when they will help us in some way. Every time we extract a piece of information or an experience from our memory, we are strengthening neural pathways that lead from our long-term memory into our working memory, where we can use our memories to think and take

actions. The more times we draw it from memory, the more deeply we carve out that pathway, and the more we make that piece of information or experience available to us in the future. So retrieval practice, in the form of either informal remembering of things, such as someone's order for a cup of green tea, or formal testing or quizzing in a school environment, paves the way for our memories to strengthen and improve.

Since the publication of the first edition of this book, cognitive psychologist Pooja K. Agarwal has become one of the leading advocates for retrieval practice in education, through her book *Powerful Teaching: Unleashing the Science of Learning* (co-authored with Patrice Bain) and her website [RetrievalPractice.org](https://retrievalpractice.org), where you can find both links to further research and plenty of examples of how to use retrieval practice in education. Agarwal points out one additional reason that retrieval practice works: because it's challenging, and we learn more from challenging tasks than we do from easy ones. You'll remember how that barista struggled for a moment when I asked her about my order, and we've all seen students struggling to answer retrieval questions in class or while they are taking quizzes. Those struggles are an essential part of the process, as Agarwal explains:

Retrieval practice makes learning effortful and challenging. Because retrieving information requires mental effort, we often think we are doing poorly if we can't remember something. We may feel like progress is slow, but that's when our best learning takes place . . . Struggling to learn—through the act of practicing what you know and recalling information—is much more effective than re-reading, taking notes, or listening to lectures. Slower, effortful retrieval leads to long-term learning. In contrast, fast, easy strategies only lead to short-term learning. (Agarwal 2019)

Reward comes from effort, in learning as in almost anything in life. Inviting our students to engage in the struggle to retrieve something from their memories, though perhaps frustrating at first, will ultimately help them obtain the long-term mastery of knowledge that will ensure success in the classroom and beyond.

MODELS

Ess?

You don't have to think too hard about how to give your students effective retrieval practice; you just have to do it. The stumbling block for instructors arises less from designing strategies than from worrying about time: how much of their classroom or planning time do they want to devote to helping students remember foundational knowledge? Small teaching can come to the rescue here, as it can help instructors envision how to incorporate retrieval practice into bite-sized moments such as the opening and closing minutes of class and into small exercises in online or blended courses.

Opening Questions

The quickest method for cultivating retrieval practice in class takes the form of asking questions, either orally or in writing, about material that either you or the students have covered already. So instead of walking into class and providing an overview of what happened in the last class period or reminding students about the larger unit in which this particular class session is embedded, ask them to provide you with that information:

- Before we start, can anyone remind me what we talked about in class on Monday? How about what we were working on last week?
- Before I introduce the third major theory we will explore in the course, what have been the two main theories we have discussed thus far?

- We've seen several experiments in this area already this semester. Can someone remind me of the results we observed?

I should note from personal experience that if you have never tried this before, you might be surprised and disappointed at how difficult students will initially find such retrieval exercises. They will stare at you with jaws agape when you ask them about material you covered the day before yesterday—material you spent many hours preparing with care in your office. Take heart and persist. The more you do it, the better they will get it—and the better they get at it, the more deeply they are learning it. If you wish to formalize this type of activity, you could follow the lead of Annie Blazer, a professor of religious studies, who begins each class with a single student providing a 3–5-minute summary of the previous class; each student does this at least once per semester (Blazer 2014, p. 344).

Naturally, the same types of questions will work for material that students have read in advance of the class or for any homework problems they have completed. Again, prior to launching a lecture or course activity for the day, ask students to provide you with the highlights of the reading or work they have completed the night before. Students in my classes engage in brief writing exercises along these lines at the start of almost every class. When I started using these exercises, at the beginning of my teaching career, I knew nothing about the power of retrieval practice for learning. I implemented them for a very different reason: to help spark discussion. I had found that just walking into the room and asking students to engage in discussion of complex issues or questions did not work very well; it worked much more effectively if I posed a question, gave them 5 or 10 minutes to write a response, and then opened up the floor for discussion. But I also used them as a form of low-level quizzing, just to ensure that students were reading. Every question requires students to do a little bit of remembering and a little bit of thinking. If students have been assigned

the first 75 pages of a novel for a class, for example, I might ask them to describe for me the primary qualities or characteristics of the narrator of the story. The word *primary* requires them to make some judgments about the variety of characteristics they might remember. Over the course of my 20 years of full-time teaching, I have come to recognize that these small writing exercises constitute the best method I have for supporting student learning in my courses—even if, as with most positive teaching experiences I have had, I stumbled upon this strategy through dumb luck or for the wrong reasons. Even though the students groan occasionally about the writing exercises over the course of the (long) semester, they note their value frequently both in conversation with me and in their evaluations of the course.

Brian Rogerson points out in his essay that one of the benefits of asking students to complete questions in writing, as opposed to just orally, is that it demands participation from all students. “These assessments,” he writes of his end-of-class questions, “attempt to survey all the students in the class, not just the more vocal ones as occurs when prompting the class for questions” (Rogerson 2003, p. 163). In other words, when you throw out your opening questions orally, you may be concerned that you are providing retrieval practice only for the students who habitually participate in class, thus leaving many other students without this benefit. However, this may not be the case. A memory experiment in which subjects were asked to view a map and to practice retrieval of the map’s features *covertly* (i.e., simply by thinking about it and not speaking or writing any answers aloud) still showed boosts to their subsequent ability to reproduce the map from memory. This research suggests that “covert retrieval practice is as good as overt practice in benefitting later retention. . . both methods produce a robust testing effect” (Pyc, Agarwal, and Roediger 2014, p. 80). Of course, this will work only if you provide the opportunity for covert retrieval, which means that you should ask questions,

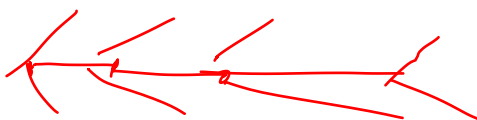
有了语音基础后，想模仿什么样的口音完全是自己的选择。许多人说起英式英语来过于夸张、拿腔拿调，非常不自然，我想这部剧是个不错的参考。

最后送你一段剧中的话：



Eric聊爱情

01:12



Love isn't about grand gestures, or the moon and the stars. It's just dumb luck. And sometimes, you meet someone who feels the same way. And, sometimes, you're unlucky. But one day, you're gonna meet someone who appreciates you for who you are.

pause for a few moments to allow everyone to engage in retrieval practice, and then invite students to share their responses. Even the students who don't speak the answer aloud can benefit from opening questions if they have a moment to think.

Closing Questions

Extrapolating from opening questions to closing questions doesn't take much creative thinking, and much of the research on retrieval practice—such as the experiment with those art history lectures—has focused on the effects of asking students questions about material they have just learned. So we know that closing questions are an effective small teaching strategy, and the same principles articulated before also apply here: focus on the key concepts that you want students to take away from the class session, and favor writing over oral questions whenever feasible. If you are looking for a simple template for closing questions that will promote retrieval practice (and give you good feedback on the learning of your students), I like the one described by Seth Matthew Fishman and Edward Wahesh in the journal *College Teaching* (Fishman and Wahesh 2020). They call it the Faculty Feedback Form, and it consists of three simple questions that students respond to in writing at the end of class:

- What is one thing I learned from our class readings?
- What is one thing I learned from today's class?
- What am I unclear [about] or would like to know more about?

Fishman and Wahesh have students respond to a fourth question that varies from week to week, and also ask students to provide a rating of their understanding of the week's material from 1 to a 100 every week. This package of activities invites students to retrieve, to think, and to reflect upon the quality of their learning, packing a lot of cognitive punch into a few minutes of class time.

One important point about these first two models is that if you ask students retrieval-based questions either at the beginning or end of the class, you will have to tell them not to look in their notebooks or their textbooks for the answers. I promise you that this will be their first inclination. Throw out a question about what you have just taught them or about what you did in class last week, and they will immediately begin flipping through their notebooks to find the answer. You will have to remind them that you are not conducting a scavenger hunt for answers or a race to see who can find the answer most quickly. You are helping them remember information, and this will benefit them only if they take the time to draw the information from their brains and not their notebooks. If you spend a lot of time reading about experiments in learning and memory, as I have done while preparing and writing both editions of this book, you will notice that almost every experiment uses a control condition in which students simply review their notebooks, textbooks, or key concepts as a study guide. In almost every experiment that I have encountered in this research, *this method proves less effective for long-term retention*. In other words, almost anything that students do with learned information or ideas or skills works more effectively than just looking at your notes about it, even doing so multiple times (Dunlosky 2013). You might want to explain to your students the purpose of opening and closing questions and how it will help them learn the material more deeply; then they won't be so baffled when you introduce small teaching activities that require them to close their books and notebooks and ask them to remember something they have learned, either at the opening or closing of class.

Online Retrieval

The challenge with implementing retrieval practice in online environments is that students are typically working away from you, so

you cannot control whether or not they have access to the materials they are tasked with remembering. So while you might be asking them to remember something, they could be just searching for the answers in their notebooks, which will not give them that valuable retrieval practice. With that said, still consider Miller's (2014) suggestions for small teaching activities or course design tweaks as ways to offer students in online or hybrid courses the opportunity to engage in retrieval practice.

Reading Checks. Retrieval practice can begin when students first engage with course materials that you have put online. Include retrieval type questions at the end of every page or section's worth of material and ensure that students can't get to the next section until they take a brief quiz. This is sometimes referred to as the "conditional release" of material within your learning management system, and is recommended by Flower Darby in *Small Teaching Online* (2019, pp. 35–38). Michelle Miller points to a study in which students who read new material and were quizzed on it in this fashion outperformed nonquizzed students on the final exam. She notes a bonus effect demonstrated by the study: "although the frequent quiz breaks kept students more attentive, they did not seem to tip them over into anxiety; students who did the interspersed quizzes actually reported *less* anxiety about the cumulative test" (p. 78).

Frequent Quizzing. Create or find as large of a question bank as possible and require students to take online quizzes frequently. If the bank is large enough, you can allow multiple retakes of the quiz, which would help boost memory because each retake will constitute another instance of retrieval practice. (If the bank is not large enough, you can run into problems with cheating.) As the experiment with the art history lectures demonstrates, and as Miller notes as well, "Short-answer questions do produce a

moderate advantage over multiple choice” (p. 108). However, as she also notes, “The best quiz is the one that students will actually *do*—so don’t let the perfect be the enemy of the good as you work to create more frequent testing opportunities” (p. 108). If multiple-choice quizzes will ease your grading burden and give you time to create more questions, use multiple-choice questions. Setting time limits on the quiz can help ensure that students don’t have a wide-open window to search around in their course materials for answers and might encourage more of them to engage in true retrieval practice on your quizzes.

Space Out Due Dates. When you are creating the due dates for your online course, space them out so that quizzes and assessments are occurring on a very regular and frequent schedule (a good practice for face-to-face courses as well, by the way). The more frequently that your students have to check in and offer some demonstration of their learning, the more often you are giving them retrieval practice. Miller recommends setting up “a recurring weekly schedule where each kind of work (discussion, quizzing, homework, any higher-stakes assignments such as major exams or papers) is due on a different day” (p. 109). Such a recommendation will help both with retrieval practice and with interleaving, another key tool for learning.

The Retrieving Syllabus

I’ll finish with a simple suggestion for the use of the syllabus to promote retrieval practice. One of the benefits that a syllabus can provide to students is helping them see the overview of the course topics and how they fit together. For this reason I advocate filling out the course schedule section of your syllabus with as much detail as possible. Include phrases or even sentences that describe

what will happen in the different units of the course so that students can keep the syllabus as a living document that guides them throughout the semester. The notion of a “living syllabus” typically refers to the idea that your course will grow and evolve over the semester, which of course any course should do in response to the needs of its students (Lang 2015). But what I mean here is a little more constrained: the syllabus has continued life because you continue to use it as a learning tool throughout the semester.

Such a living syllabus can serve as an excellent small teaching retrieval tool. Require the students to bring their syllabus to class every day, and occasionally use those precious opening and closing minutes of class for a very simple exercise. Have your students pull out their syllabus, and then point them to a previous day’s content and ask them to spend a few minutes writing down what they remember about it. You can do this informally, by having them do so in their notebooks, or you could do it in the form of a writing exercise that you collect. You could even do it orally. Point to the date, give them a minute to think, and then collectively ask the class to remind you about what key concepts or skills they took away from that class period or that course unit. Too often, the course syllabus makes an appearance on the first day of the semester and then remains buried in a folder for the rest of the course, serving only as a list of due dates or assignments to complete. Use your course syllabus as a means to foster retrieval practice through brief, small teaching moments in individual class sessions.

PRINCIPLES

Retrieval practice will help your students retain foundational material, which they are most likely to encounter in introductory or entry-level courses in your field. Hence when you are

considering how to incorporate retrieval into your teaching repertoire, **look first to the lower-level classes you are teaching.** The following principles can help guide you through the use of the models above or through the creation of alternative retrieval exercises tailored to your courses.

Frequency Matters. The first and last implication of all of this research on retrieval practice is very straightforward: the more students practice retrieval, the better they learn. Frequency matters. The easiest way to implement frequent practice is through regular quizzing. That should be your default strategy. Give quizzes at least once a week, and don't hesitate to give them every class. But all of that quizzing can mean lots of grading, especially if you are using short-answer questions. If you don't want to rely exclusively on quizzes, mix quizzing with small teaching questions (either orally or in writing) at the opening or close of class. Whatever strategy or mix of strategies you choose, implement them as frequently as possible given all of the other demands on your time.

Align Practice and Assessments. Whatever type of memory tasks you will ask of your students on your high-stakes assessments (such as midterms and exams) should appear in the retrieval practice you use. If you ask students to remember names and dates of key thinkers in your field on the final exam, make sure they are getting practice in remembering those thinkers throughout the semester. If you give multiple-choice final exams, use polling questions in class to give them practice in multiple-choice retrieval. If you give them essay exams that require some memory mixed in with thinking, give them writing exercises in class in which they have to answer final exam-type questions.

Require Thinking. Remember Willingham's axiom that we remember what we think about? Help your students remember by giving them something to think about. Your retrieval practice

might sometimes take the form of simple memory exercises—after all, we likely all have certain key facts or basic information that we want students to have mastered. For example, I want students in my British literature survey course to know that Robert Burns is Scottish because his Scottish identity helped influence much of what he wrote. They can't do higher order analysis of a Burns poem on a final exam if they forget that key fact. **But rather than asking students to practice remembering his nationality by selecting it from a list, I can ask them short-answer questions that require them to remember that fact and put it to some use: How does the national identity of Robert Burns influence his writing?**

SMALL TEACHING QUICK TIPS: RETRIEVING

Memory retrieval works especially well in brief classroom interventions. You can find room for retrieval in almost any class period or learning session, even if it takes only a minute. But my favorite opportunities for retrieval appear in the opening and closing moments of class, or in the form of regular quizzes or writing exercises.

- Open class periods or online sessions by asking students to remind you of content covered in previous class sessions; allow students time to reflect for a few moments if you do so orally.
- Close class by asking students to write down the most important concept from the homework and the class period and one question or confusion that still remains in their minds.
- Close class by having students take a short quiz or answer written questions about the day's material or solve a problem connected to the day's material.

- Give frequent, low-stakes quizzes (at least weekly) to help your students seal up foundational course content; favor short answers or problem solving whenever possible so that students must process or use what they are retrieving.
- Use your syllabus to redirect students to previous course content through quizzes or oral questions and discussion.

CONCLUSION

I have heard college and university professors express reluctance at the use of regular quizzing because they feel like it infantilizes the students or changes the atmosphere of the classroom from one of shared learning and discussion to one of testing and evaluation. I had those exact same feelings about quizzing when I began my teaching career. I just wanted to engage in interesting discussions with my students about literature and not impede our relationship with heavy-handed tactics like quizzing and testing.

However, I had too many experiences of having interesting discussions about literature with students who had not done the reading (but who were very good at faking their way through discussions) and who remembered nothing of what we had discussed at the end of the semester for that perspective to last very long. So I understand any emotional hesitation you might feel at the prospect of regular retrieval practice in your classroom, but remember that such practice helps your students learn foundational knowledge as effectively as anything else we know. Think about retrieval practice as I have been arguing for it here: as an activity that lends itself perfectly to small teaching and therefore doesn't require you to devote huge amounts of time or energy to it.

If you consider it in that light and push yourself to implement regular quizzing or retrieval practice, you will likely find that your students are grateful for it by the end of the semester. In

addition to the memory practice it provides them, it also ensures that they stay on top of the reading or homework, which means they won't find themselves stuck at the end of the semester with lots of catching up to do. As always, you can help them recognize the value of those quizzes by teaching transparently. Tell them what the research says about the value of quizzing and retrieval practice and about your decision to use it. They still might not love taking quizzes during the long slogging weeks of October, but they will recognize their value and reap the rewards on those final assessments in December.

Chapter 3

Interleaving

INTRODUCTION

One of the sabbatical projects I undertook while writing the first edition of this book was learning Spanish, a task I had attempted but then abandoned during graduate school many years ago. Although ostensibly I embarked upon this more recent endeavor in preparation for some upcoming travel to Latin America, in truth I count studying and learning languages as one of my favorite pastimes. (I will pause here to allow you to savor the fact that you probably lead a more socially engaging life than I do.) My school language learning includes Latin, Greek, and French, but I have also made independent efforts to learn Spanish, Italian, and Gaelic at various points in my life. Because I have spent so many hours memorizing foreign language vocabulary and studying grammatical structures of other languages, the process has become one with which I am comfortable and familiar. Even though it had been quite a few years since I launched a full and earnest effort to master a language, I assumed that my Spanish study would come easily enough as long as I put in the requisite time and effort.

My course of study began with an online program that I hoped would guide me through the early stages of review and basic acquisition, after which I would expand to other activities

like reading novels or watching television shows in Spanish. For a month or two, I spent 15 minutes every day listening to brief sentences in Spanish, repeating them back into the computer microphone, translating Spanish sentences into English and vice versa, and taking occasional quizzes. The individual lessons of the program were broken into segments that took about five minutes to complete, which meant I could complete three new ones every day. Each new segment included a small measure of reinforcement of the material I had already learned, but the lessons focused mostly on acquiring new vocabulary or identifying new rules of grammar or syntax. A month into following this schedule of three new lessons per day, I found myself increasingly forgetting vocabulary I had learned just days before and regularly failing the occasional timed quizzes. I would learn the word for “tie” (*corbata*), and then the next day mix it up with the word for “belt” (*cinturon*). A few weeks later, one of those words would pop up for review, and I wouldn’t remember either of them. My progress in understanding Spanish seemed very slow in contrast to my previous experiences. Every lesson felt like a new struggle to me. I assumed that the program—which multiple people had recommended to me—had been constructed by folks who knew something about language acquisition and that therefore the problem must lie with me. Either I was not spending enough time on my study, or my aging brain was no longer as adept as it once was in learning languages. All I could think to do was redouble my time and effort.

Then one day I noticed a tab on the home page labeled Strengthen Skills. I clicked on it, and it took me through a five-minute review session that mimicked the activities of the normal lessons but introduced nothing new; it was like a remixed return of exercises I had completed in the past. At first, I found it frustrating to complete these exercises since I was stumbling over vocabulary that I had supposedly learned already, but I began gradually incorporating more and more of these review sessions

into my learning time. Eventually my routine shifted from three new lessons per day to one new lesson per day and two review sessions. Within weeks of making this change I felt the budding mastery that had been eluding me begin to emerge; I began regularly acing the timed quizzes and feeling much more comfortable with my pronunciation efforts. Of course, my progress through new material slowed down, but this seemed like a small price to pay for a much firmer understanding of the new material through these repeated review sessions. Perhaps most important, what had felt like a painful struggle to me now became enjoyable.

IN THEORY

The learning principle that helps explain this improvement in my language acquisition skills is called interleaving, and it involves two related activities that promote high levels of long-term retention: (a) spacing out learning sessions over time; and (b) mixing up your practice of the skills you are seeking to develop. The learning literature contains bodies of research on both of these practices, which scholars usually distinguish with the terms spacing and interleaving. I'll follow their lead and use those two different terms in what follows, and the models in this chapter will include recommendations for both spacing and interleaving.

A study conducted almost 30 years ago on French language acquisition in an American high school provides an excellent illustration of the power of spacing (Bloom and Shuell 1981). The researchers divided around 50 students into two groups and charged each group with learning 20 new French vocabulary words in different ways. The first group had a single 30-minute session in which they studied the new vocabulary words and completed three separate tasks on them, such as filling in the French word after receiving the English equivalent. The second group

had the exact same length of study time and the exact same set of written exercises, but they were separated into three 10-minute study periods over the course of three consecutive days. The contrast between these two methods is usually described in the literature as *massed* versus *spaced* (or sometimes *distributed*) learning. In massed learning, students complete the study or learning task in a single block of time; in distributed practice, students space out their learning sessions over more than one session. At the end of the study periods for both groups in this experiment, the students were given a vocabulary test on the words; both groups averaged about 16 of 20 words correct. This finding will appear again and again in the literature; for short-term retention, massed practice can be as effective (and sometimes more effective) than distributed practice. The researchers then returned to the classroom a week later, without any prior warning to the students, and tested them on the vocabulary again. This time the results diverged sharply: the massed practice students remembered around 11 of the vocabulary words, whereas the spaced practice students remembered around 15. Remember that both groups had the same total learning time and completed the same tasks; only the spacing of their learning activities differed.

A substantial body of research has demonstrated the power of spaced learning. “The benefit of spaced practice,” write Megan Sumeracki and Yana Weinstein in *Understanding How We Learn: A Visual Guide* (with illustrations by Oliver Caviglioli), “is arguably one of the strongest contributions that cognitive psychology has made to education” (2019, p. 99). The theory that explains the power of spaced learning stems at least in part from what we have learned about the importance of retrieval practice. One of the challenges to our memories is the ability to pull desired information from our long-term memories when we need it. The more times we practice drawing specific skills or information from our long-term memory, the better we get at it. When we engage in massed

learning, putting all of our study into one time period, we never have to access the learned material from the deeper recesses of our long-term memory. By contrast, if we use spaced learning to allow some time for the forgetting of learned material to set in, we are forced to draw material from our longer-term memory when we return to it. Spacing out learning forces us to engage at least partially in memory retrieval.

That forced cycle of forgetting and retrieving is only half the explanation for the power of spaced learning. As the authors of *Make It Stick* explain, the time that intervenes between spaced learning sessions also allows our minds to better organize and solidify what we are studying:

Embedding new learning in long-term memory requires a process of consolidation, in which memory traces (the brain's representations of new learning) are strengthened, given meaning, and connected to prior knowledge—a process that unfolds over hours and may take several days.

Rapid-fire practice leans on short-term memory. Durable learning, however, requires time for mental rehearsal. . .

Hence, spaced practice works better. The increased effort to retrieve the learning after a little forgetting has the effect of retriggering consolidation, further strengthening memory. (Brown, Roediger, and McDaniel 2014, p. 49)

Our brains need time to undertake the processes of encoding, consolidating, and organizing newly learned material, and the gaps between spaced learning sessions allow it that time. If you have ever slogged your way through some difficult learning exercise, left it in frustration, and then—hours or days later—returned to it with a mysteriously firmer grasp of it than you had previously, you have experienced the phenomenon described by the authors of *Make It Stick*. I remember this happening to me time and time

again when I played the piano more regularly. I would stand up from a practice session convinced that I would never master some difficult passage and then sit down the next day and find that it had mysteriously become much easier than it was the day before.

The implications of this principle are clear enough for both learners and teachers: we should help students space out their learning both in how we design our courses and in how we encourage them to study. However, we can help our students even further if we coordinate their spaced learning with interleaving, a related approach to helping our students master new skills. Interleaving refers to the strategy of learning and practicing the different components of a skill in mixed order. If I were learning to play golf, for example, or trying to improve my skills at the game, I could spend an entire week working on my driving, another week on hitting iron shots, and a third week on putting. This would be what researchers call blocked practice. Interleaving, by contrast, would have me mix up my practice: a couple of days on each skill in every week. The research on interleaving suggests very clearly that the second option will be more likely to improve my skills in the long term. It's easy to see why in this example. When I am playing an actual game of golf, I don't hit 18 drives or 18 putts in a row. I hit a drive, then an iron (or two or three), and then I putt. Throughout the game I am having to make small adjustments to my swing with each different club I use (since they are all slightly different sizes and shapes). When I block my practice, and hit the same club over and over again, I don't have to make those adjustments. Interleaved practice forces me to learn not only how to hit each type of club, but also how to adapt my swing from shot to shot—which is the really essential skill you need to play the game well.

Studies on the power of interleaving in academic settings confirm this explanation. Consider a frequently cited experiment in which students were tasked with the challenge of learning to solve math problems involving different geometric shapes (Rohrer

and Taylor 2007). In this experiment the students all received brief tutorials on how to calculate the volume of four different geometric shapes, including seeing a worked example, and then were asked to solve 16 different problems that required them to use what they had just learned. The tutorials and problem-solving sessions took place on two separate occasions, a week apart. In one group, the Blockers, the students had a tutorial and then solved four problems on it; had a second tutorial and then solved four problems on it; and so on. In the other group, the Mixers, the students received all four tutorials at once and then were given the 16 problems in random order. While the students were working on the problems initially, the Blockers performed better. During the first learning session, for example, the Blockers solved 89 percent of the problems correctly; the Mixers solved only 60 percent of them correctly. One week after the practice sessions were completed, the groups returned to the laboratory and were given a new set of eight problems, in random order, two on each of the four shapes. The difference between the groups is astonishing: the success rate of the Blockers dropped down to 20%, whereas the success rate of the Mixers improved to 63%.

In this experiment, both groups engaged in spaced learning; they had two distinct sessions, separated by a week, and the test was given a week after that. We don't have a comparison group in which, say, students completed 32 problems in one massed session instead of the two separate sessions spaced a week apart, but we can assume from previous research on massed versus spaced learning that both the Blockers and Mixers would have outperformed that group. So, given that both groups engaged in spaced learning, this experiment particularly highlights the benefits of interleaved learning: mixing your study or practice as well as spacing it. The authors of the study present this brief explanation for why they believe the Mixers so definitively outperformed the Blockers: "The superior test performance after mixed practice is, in our

view, attributed to the fact that students in this condition were required to know not only *how* to solve each kind of problem but also *which* procedure (i.e., formula) was appropriate for each kind of problem (i.e., solid)” (Rohrer and Taylor 2007, pp. 493–494). In other words, the Mixers had to learn not only how to plug and chug the mathematical equations but also how to identify the *type* of problem they were seeing and to select the formula that would work for that problem. They could not work on autopilot, as a student might do in a class session in which he learns Formula A and then applies it to Problem Type A for an extended period of time, knowing that Formula A will always work for Problem Type A, and every problem he will see in the session will be Problem Type A. Hence, “a significant advantage of interleaving and variation,” argue the authors of *Make It Stick*, “is that they help us learn better how to assess context and discriminate between problems, selecting and applying the correct solution from a range of possibilities” (Brown, Roediger, and McDaniel 2014, p. 53). And this is important, as they note, because real-world performance contexts require this skill: in life, as on final exams (and in golf), “problems and opportunities come at us unpredictably, out of sequence. For our learning to have practical value, we must be adept at discerning ‘What kind of problem is this?’ so we can select and apply an appropriate solution” (p. 53). Blocked learning does not require students to make such choices about which learned skill to apply in which context.

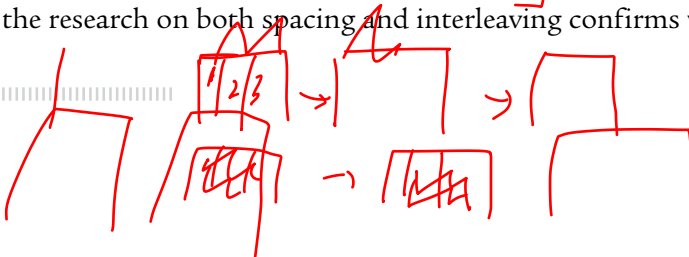
This explanation for the limits of blocked practice and the benefits of interleaving points to a deep and fundamental challenge that all learners face: transferring learning from the original context in which we encounter it into novel or unfamiliar contexts. A great deal of research has been done in this area, and the consensus has been that fundamentally we are not very good at doing this. “Transfer,” writes Michelle Miller in *Minds Online*, “is remarkably hard to achieve, a particularly unsettling fact given

that it is also such a high-stakes issue; after all, an education that doesn't transfer isn't worth much" (Miller 2014, p. 130). We learn in specific contexts, those concepts become familiar to us, and we have trouble transferring that learning into other contexts. So students who learn a specific writing skill in my composition class never think to apply it to the history paper they are writing; students who master the scientific method in biology don't think to apply it in the psychology course they are taking. **Blocked study or practice deepens our association between a learned skill or concept and the specific context in which we learned it; interleaved learning, by contrast, forces us into frequent transfers of information and skills across contexts, which helps us develop the ability to recognize when a learned skill might apply in a new context.** The students in the math experiment, when they were taking that final test, were faced with novel problems in random order. The students who had engaged in mixed practice were much more effective than the blockers at rooting around in their memory for the full set of skills they had learned and applying them in this new context. Cultivating the ability of our students to draw from memory and apply learned concepts or skills to new situations is, as Susan Ambrose and her colleagues argued, the "central goal of education" (Ambrose, Bridges, DiPietro, Lovett, Norman 2010, p. 108). Interleaved learning facilitates that goal more effectively than massed learning.

Before we push into the models for interleaving in higher education pedagogy, though, I have to offer one essential clarification. In the initial learning phase, blocked study or practice is not a bad thing—and for some types of learning tasks it might even be a necessary thing. A study by Shana Carpenter and Frank Mueller, two psychologists at Iowa State University, compared the effects of blocked and interleaved practice on students who were learning the pronunciations of French words (Carpenter and Mueller 2013). Over the course of several experiments, they

found consistently that the students who had the opportunity to repeat the pronunciation of familiar words over and over again in blocked fashion outperformed those who learned those pronunciations in interleaved fashion. Their survey of the literature also points to one or two experiments in which blocked learners have outperformed interleavers on certain types of tasks (although they acknowledge that the bulk of published studies supports interleaving). The final recommendation they make in their conclusion, though, seems like an eminently sensible one: “Rather than using a schedule that is exclusively blocked or interleaved, it may be more advantageous to start with a blocked schedule and then transition to interleaving” (p. 680). Blocked study or practice, it seems to me, is an appropriate first step for any learning activity. As Benedict Carey put it, “It’s not that repetitive [or massed] practice is *bad*. We all need a certain amount of it to become familiar with any new skill or material” (Carey 2014a, p. 157). Indeed, I suspect most of us introduce new material to our students, or learn it ourselves, by blocking the study or practice of it. We have to begin the learning process by spending some concentrated time or effort on the task. The argument I am making here is not to eliminate blocked practice but to use interleaving to require students to return continuously, in different contexts, to material they have learned already. Blocking on its own is not a problem; blocking without interleaving—otherwise known as cramming—produces wonderful short-term retention but will leave our students without the long-term retention that will enable them to extend their learning beyond the final exam.

I should conclude by noting that interleaved practice can seem messy and might even provoke frustration from you and your students since it would be much neater and cleaner to march your way through the learning of new skills in order, mastering them completely before moving onto the next. Indeed it would, and the research on both spacing and interleaving confirms what



you suspect: learners often find it frustrating. I experienced this frustration myself when I began using that Strengthen Skills tab in my language-learning program and found that I didn't know nearly as much as I thought I did. Research also tells us that massed practice works very effectively for short-term learning, which is why students like it and why they can often perform well on exams when they engage in massed learning exercises like cramming. As long as they are cramming immediately prior to the exam, they will see some benefit from their exertions (Sumeracki, Weinstein, and Caliglioli 2019, pp. 90–92). But if they want their learning to last beyond the next few hours or the next day, they have to take a different approach.

MODELS

The application of the small teaching philosophy to the learning principle of interleaving occurs less in the form of specific in-class activities than in the form of tweaks or modifications to your course design. So the following models focus less on discipline-based examples and more on how to achieve interleaving in three different contexts: (a) through the design of your assessment plan, especially exams and quizzes; (b) through the organization of your class time; and (c) through the use of an online course management system.

Cumulative Exams

If you combine the research on the importance of retrieval practice and the power of interleaving, the implication is an obvious one: all major exams in your course should be cumulative. Research on learning supports this implication. In one study of cumulative versus noncumulative exams in psychology courses, researchers

analyzed the scores of students in a cluster of psychology courses on a postcourse assessment; students who had taken a cumulative final exam scored substantially higher on the postcourse assessment than those who had taken noncumulative finals (Khanna, Brack, and Finken 2013). For some of the courses, the positive learning effects of the cumulative final exam persisted as long as 18 months after the completion of the course.

More generally, every major assignment should require students to draw—at least a little bit—on information or concepts or skills they have learned in previous units. This does not have to mean that the third exam of the course must be divided into three parts, one on each of the first three units. It may be that the third exam focuses primarily on the third unit, with two-thirds or three-quarters of the tested material deriving from that section of the course. But the final third or quarter should require students to return to material from earlier parts of the course. You can even accomplish this in a less obvious way by giving assignments or asking exam questions that require students to compare current content or skills with previously learned material. In my literature survey course, which divides into four units over the course of the semester, each exam requires students to answer three or four large essay questions. After the first exam, one of those questions always requires them to compare an author or event or trend from the current period with one from a previous period. They are warned about this, which gives me an opportunity to remind them about the importance of continually returning to the authors and ideas we have already discussed.

Cumulative Quizzes

Quizzes represent another excellent opportunity to leverage the power of spacing and interleaving in your courses. Select some reasonable percentage of your quizzes that will be devoted to

previously covered material and stick with it throughout the semester. If you give 10-question multiple-choice quizzes on a weekly basis, set aside two questions for previously learned material. If you give one-question writing-based quizzes, as I do, ensure that every third or fourth quiz requires students to return to previously learned material. In *Powerful Teaching*, Patrice Bain describes her use of what she calls “Big Basket Quizzes,” which occur at the end of every week (Agarwal and Bain 2019, pp. 98–99). The basket contains the quiz questions that she has asked all throughout the course. Each end-of-week quiz includes questions focused on the material from the current week as well as some questions pulled from the big basket. This process randomizes the material that students will return to each week, which you might find easier to implement than overthinking the process and creating some kind of algorithm for how and when previous questions appear again. As the course progresses throughout the year, Bain culls from the basket questions which are focused on less essential course content, thus ensuring that the questions students encounter from previous units are the most important ones to be able to answer.

Overall, you should consider your total package of quizzes and exams as the ideal tool for continuously reinforcing learned material from the first week of the semester to the last. If you don’t give a cumulative final exam, you are essentially conveying to students that what they learned in the first weeks of the semester don’t matter anymore. If you do give a cumulative final exam but not cumulative mid-terms or quizzes that test them on previously learned material, you are not giving them the kind of help they really need to solidify and enhance their early-semester learning on the cumulative exams.

I would be omitting a truth you would quickly discover on your own if I did not reiterate at this point that students might not respond with unbridled enthusiasm (at least initially) to either cumulative exams or cumulative quizzes. Just as I felt frustration

when I first began to test myself on previously learned Spanish vocabulary and quickly realized how little of it I remembered, your students might feel initial frustration at the expectation that everything they have learned remains on the table for all of their quizzes and exams. Maryellen Weimer, in a post on cumulative exams on the website Faculty Focus (Weimer 2015), offers some excellent suggestions for helping reconcile students to cumulative exams, all of which sit perfectly within the framework of small teaching activities, requiring just a small investment of class time:

- Open each class session by posting a test question from a previous exam or a potential test question related to previous course content. Give students time to consider and discuss their answers.
- Close class sessions by asking students to create a test question based on that day's material, and pose that question back to them in future class sessions.
- Open or close class sessions by asking students to open their notebooks to a previous day's class session and underline the three most important principles from that day; allow a few moments for a brief discussion of what they featured from their notes.

Strategies like these give you the opportunity to announce to students from the beginning of the semester that all learning in the course will be cumulative, and they give your students the help they need in preparing to succeed on cumulative exams.

Mixing Classroom Practice

In Chapter Five I will make the case that you should give students time in the classroom to practice whatever kinds of skills they will need to complete for your assessments. If you are giving cumulative

exams and mixing up skills and knowledge in your quizzes, you need to provide opportunities for students to practice these activities in class. Your final assessment will almost certainly not provide students with an explanation for what skills or knowledge they need to apply on every question of the exam, or on every page of the paper. It will require them to discriminate and adapt, to understand how to take the many skills they have learned in your course and apply them in novel contexts. Your students should get some practice at doing these things in class. To accomplish this, you'll have to consider how you can make practice sessions in your classroom opportunities for spacing and interleaving. If you teach writing, you probably have students write in class; what would spacing and interleaving look like there? If you teach math, you have students solving problems in class sometimes; what would spacing and interleaving look like there? This can be a challenging question to answer, but it's worth at least a little reflection.

Every year or two I teach Introduction to Literature, a course in which we help students learn to interpret literature by marching them through lots of reading in three major genres: poetry, fiction, and drama. Almost every literature textbook on the market, and almost every syllabus I have seen for this kind of course, has students learning how to interpret these three genres in blocked ways. We spend five weeks working on poetry, studying things like symbolism and imagery; five weeks working on fiction, studying things like character and setting; and five weeks on drama, studying things like irony and performance. This obscures the fact that almost any of the interpretive tools they are learning can be applied to any of the three genres. Symbols appear in poems, but they appear in stories and plays as well. Plays have characters, but so do stories and even poems, in the form of the speaker. In my introductory literature course, students spend plenty of time working individually or in groups engaging in interpretive practice: I might put them in groups and ask each group to identify

all of the images and potential symbols they can find in a poem, or to analyze a story through the lens of setting and character. If I want them to interleave, at least every once in a while I need to give them a work of literature, along with a list of every interpretive strategy we have studied in class (from all three genres), and say: you tell me which strategies we should use here, and don't limit yourself to the ones we discussed in relation to that genre. In fact, to really drive home the point, I might require them to select at least one interpretive strategy that we *didn't* consider when we were learning that genre. This will force them to consider which strategies to apply in a novel context, and how to do so—which are the core skills that interleaving should help people master.

Consider what the equivalent of this would be in your course. What would it look like to set aside 15 minutes of class time every week or every other week, give students a novel problem or question and a list of everything they have learned thus far, and say: How will you solve it? The more of this work that your students do, the more successful they will be when they get to the novel context of your final assessment—and the novel contexts they will encounter beyond your course.

Online Learning Environments

In *Minds Online*, Michelle Miller argues that online learning environments provide an ideal tool for creating spaced and interleaved learning experiences for our students. In a fully online course, she suggests that instructors “set up a recurring weekly schedule where each kind of work (discussion, quizzing, homework, any higher-stakes assignments such as major exams or papers) is due on a different day. You can set things up so that students are welcome to work ahead, but can't fall behind; some will manage to mass their work anyway by turning everything in extremely early, but those students are exceedingly rare” (Miller 2014, p. 109). For the

majority of our students the use of such staggered deadlines will have the desired effect, especially if material from different weeks or units regularly appears in the various assessments. Miller also notes that “when you prioritize spacing and interleaving in your course design, you create a much more complex set of deadlines for students” (p. 110), which may lead to hardships for students who sought out the online learning environment because they needed a more flexible learning schedule. Here, as in many areas of teaching, you may not be able to distribute deadlines quite as much as the literature on interleaving would recommend. Even a small bit of attention to the distribution of deadlines and spacing of material should help.

For blended courses, you might think about how the class and online components can work jointly to combine blocked and interleaved learning. Perhaps when you are in the room with students you concentrate on exposure to new content, blocking that material into your 50- or 75-minute face-to-face sessions. Especially if you meet the students only once per week in person, you might find you need to use that space for blocked learning to give them enough initial mastery and confidence to tackle the online work. In the online assignments and discussion boards, by contrast, you could continually push students back to older material or ask them to draw connections between the material covered in the most recent class and previously covered material. You can just as easily reverse this strategy, giving online assignments in ways that will focus their attention on specific skills and using your face-to-face time to require them to mix practice and pull skills and ideas from throughout the course. Neither approach seems inherently better to me; it likely depends on the type of material you are teaching. However, it seems to me like a natural fit to make deliberate use of face-to-face and online course components to support both blocked and interleaved learning, whether you are doing so in a fully blended course or even in a traditional

face-to-face course that uses any of the features of a learning management system, including quizzes or discussion boards. All these recommendations represent small design shifts that can be addressed as you are laying out the basic plan for your course.

PRINCIPLES

Remember that you can use both spaced learning and interleaving to boost long-term retention. The smallest teaching step would be to find simple ways to space out student exposure to key course material through cumulative quizzes and exams. If you see positive results, you can then work more gradually on designing an assessment system that creates more fully interleaved learning.

Block and Interleave. Blocked learning sessions probably form the backbone of the course plan for many instructors, including me. The research cited in this chapter does not require you to subtract blocked learning sessions from your course; it recommends that you add spacing and interleaving to them. To gain some initial mastery of new content or a novel skill, learners may well need some initial sessions of blocked or massed practice, as the experiment with students learning French pronunciation would suggest (Carpenter and Mueller 2013). Don't hesitate to dig into a focused problem-solving session or to spend concentrated periods of time introducing new content. Just ensure that students return to that material over and over again throughout the semester, encountering it in multiple contexts so that they can continually develop and refine their knowledge and skills.

Keep It Small, Keep It Frequent. As with retrieval practice, frequency matters when it comes to interleaving. Students should have the opportunity to return to key course concepts or skills multiple times over the course of the semester, both in class and

on their assessments. If you provide at least one opportunity for interleaving in every week or class unit, and on every quiz or exam, you should be able to cycle back to major elements of the course several times. To help you accomplish this task, keep your interleaving sessions in class small. As with prediction and retrieval, you can use the opening and closing minutes of class to link students to previous course content or even to point them toward future content. Use those windows to pose and discuss previous test or assignment questions, have them solve an additional problem, or highlight and review older material.

Explain and Support. Learning through interleaving can seem frustrating to learners, at least initially. In experiments in which learners have the opportunity to learn through blocked or interleaved practice, they overwhelmingly choose blocked practice because it gives them a feeling of mastery over the material. Pausing before you have fully mastered something can feel frustrating, as can be the demand to recall material or practice skills you thought you had mastered but then realize you don't know as well as you had imagined. Make sure that you speak to your students about the benefits of interleaving, about the nature of your assessments, and about the differences between short- and long-term learning. Since you might find that initially student grades on cumulative exams are lower, consider giving less weight in the overall course grade to early exams, allowing the students an exam or two to accustom themselves to the challenging nature of interleaved learning.

SMALL TEACHING QUICK TIPS: INTERLEAVING

We can once again look to those fertile opening and closing minutes of the class period for interleaving techniques. But every one

of your assessments, from quizzes to papers and tests and presentations, can become a potent tool in your interleaving arsenal.

- Reserve a small part of your major exams (and even the minor ones, such as quizzes) for questions or problems that require students to draw on older course content.
- Use quiz and exam questions that require students to connect new material to older material or to revise their understanding of previous content in light of newly learned material.
- Open or close each class session with small opportunities for students to retrieve older knowledge, to practice skills developed earlier in the course, or to apply old knowledge or skills to new contexts.
- In blended or online courses, stagger deadlines and quiz dates to ensure that students benefit from the power of spaced learning. In blended courses mix the work you do in the different modalities: first exposure in the classroom and review online or vice versa.

CONCLUSION

A reminder about the process by which we grow and evolve as teachers might be the most convincing proof I can offer on the power of spacing and interleaving. If you were to take just one of the models that I have presented in these first three chapters, and try to incorporate it into all of your courses on a weekly basis, you will of course get better at it over time. You'll have a much stronger understanding of how to use the technique effectively in six months than you do the first time you try it. Your improvement will stem in part from the fact that spacing and interleaving are supporting your growing mastery. If you put a small teaching

technique on a weekly schedule, you will return to it after time has elapsed in each new week, and then for at least one longer interval of a summer or winter break. During that time away from the teaching, your brain will be working behind the scenes, consolidating your knowledge of the technique, and devising new ways to try it. Each time you step into the classroom with the intention to use it, you'll have to retrieve knowledge from your previous attempts, remembering what worked and what didn't work, and correcting your technique. A little bit of prediction, retrieval, and spacing will all be at work in this process.

But if you commit to trying a new technique in all of your courses—in my case, I might be trying it in my English composition course and my British literature survey course—than you are going to be practicing it in multiple contexts, alternating back and forth between them, just as the research on interleaving would recommend. That movement between the different courses will help you learn to discriminate and fine-tune your understanding. At first, you will try the technique in the same way with all of your courses. Eventually you will start to recognize that each course requires its own nuances of application: In my composition course I might do it this way; in my literature classes I might do it another way. You might come to realize that a particular technique works really well just as I have described it for your first-year students; for your seniors or graduate students you have to do things a little bit differently. You might find that some techniques work really well in some contexts or not in others—a realization that will push you further in your thinking about teaching and open up new insights for the future.

In the closing years of the nineteenth century, William James gave a series of presentations in different venues in which he presented some ideas for how teachers could benefit from discoveries in the budding discipline of psychology. In the book that he

later wrote based on those talks, published more than a century ago, he notes the importance of spacing and interleaving for deep learning:

You now see why ‘cramming’ must be so poor a mode of study. Cramming seeks to stamp things in by intense application immediately before the ordeal. But a thing thus learned can form but few associations. On the other hand, the same thing recurring on different days, in different contexts, read, recited on, referred to again and again, related to other things and reviewed, gets well wrought into the mental structure. (James, 1900, p. 129)

The English professor in me loves this quote so much for the elegance of that final phrase: “well wrought into the mental structure.” If that’s the kind of learning you seek for your students, find ways to help them space and interleave.

info ⚙️ 为了xx —

Read-digest-apply-internal.ize
Happy retrieving!

skills

Effortful retrieval makes for
stronger learning and retention.

Peter C. Brown

retrievalpractice

Easy mode

- ↖ cinch
- ↖ No-brainer
- ↖ Low-hanging fruit

1. 这个词什么意思？

potency → *imponent* → *unmi*
axiom
pithy
dumb-luck →

2. 这个词还让你想到了哪个词？

3. 我们学这个词的时候还学了哪个词？

→ a person of routines

Lodge it to memory →

Potency

Pithy

Bite-size ~~↖~~

f₁₂

4. One-sentence challenge

1). 什么是retrieving ? 为什么好用 ?

↳ retrieving 是_____，它的好处是_____.

↳ 2) 什么是interleaving ? 为什么好用 ?

5. 昨天学的内容对你最大的启发/帮助是什么 ?

Contents

Acknowledgments	ix
About the Author	xiii
Preface to the Second Edition	xv
Introduction: Small Teaching	1
Part I <u>Knowledge</u>	
1 Predicting	19
2 <u>Retrieving</u>	41
3 Interleaving	63
Part II <u>Understanding</u>	
4 Connecting	91
5 Practicing	113
6 <u>Explaining</u>	135
Part III <u>Inspiration</u>	
7 Belonging	163
8 Motivating	193
9 Learning	219
Conclusion: Beginning	237
Works Cited	241
Index	249