



Retrieval Practice
retrievalpractice.org

HOW TO USE SPACED RETRIEVAL PRACTICE TO BOOST LEARNING

Shana K. Carpenter, Ph.D.

Pooja K. Agarwal, Ph.D.

©2019

IOWA STATE UNIVERSITY





If you want to improve students’ grades, where should you start? Conventional wisdom tells us that the key to mastery is to spend more time learning. A student who performs poorly on an exam is likely to spend more time studying for the next one. And a teacher who witnesses her students struggling to grasp a difficult concept is, understandably, likely to spend more time teaching that concept in the future.

But, is more always better? We know that retrieval practice is the key to successful learning. Just like a workout, retrieval exercises our “memory muscles” and strengthens learning.^[1] So more retrieval practice, just like more exercise, should lead to better results, right? If a student wishes to score higher on her next Spanish exam, she should spend more time practicing retrieval of her Spanish vocabulary and grammar rules.

However, research reveals that the key to successful learning via retrieval is not so much the total time spent learning, **but the way in which that time is distributed**. “Spaced practice” is a technique that can drastically improve learning without changing the amount of time spent learning.

In this guide, we discuss how to use spaced practice to improve learning. This technique—supported by hundreds of studies and over a century of research—is simple and easy to implement, works for any type of learning, and produces long-lasting results.



WHAT IS SPACED PRACTICE?

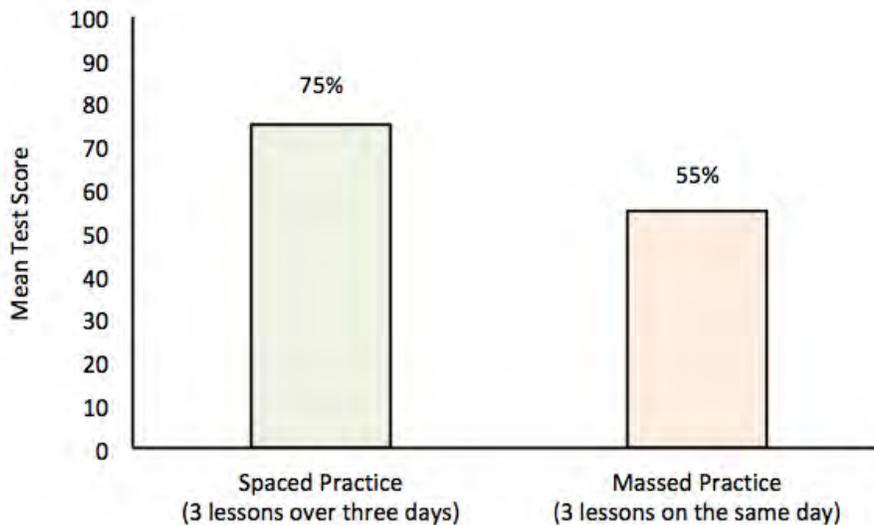
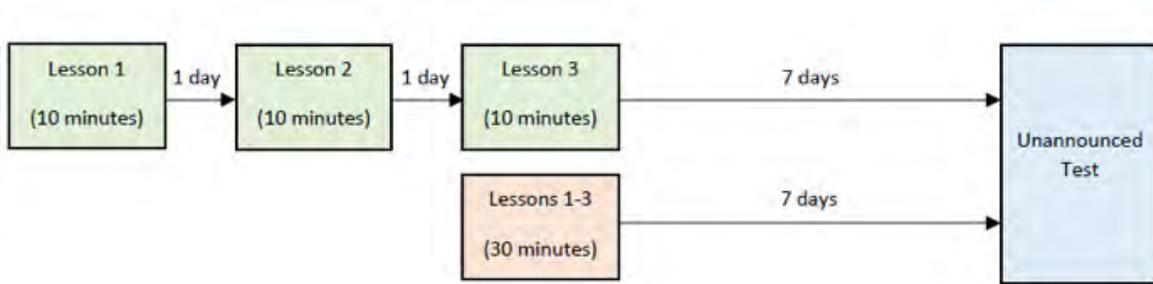
Spaced practice involves taking a given amount of time devoted to learning, and arranging that time into multiple sessions that are spread over time. In this way, the learning sessions are said to be “spaced” apart in time. This can be compared to the more popular approach—known by many as “cramming”—in which students do all or most of their studying in one long session shortly before the exam.^[2]

For example, the night before a Spanish exam a student might study 50 vocabulary words by repeatedly trying to retrieve the English translation for each of the Spanish words (Zapato – Shoe). Let’s say the student goes through the whole list three times practicing retrieval of the translations. An alternative approach is to practice retrieving the translations for the list of 50 vocabulary words on three separate occasions—one time a week before the exam, again a few days later, and again a few days after that.

Critically, both approaches involve the same amount of time learning, but differ in how that time is scheduled. **Simply spacing learning opportunities across multiple days leads to much higher achievement than studying the same amount of information all in one session.**

In one study, high school students learned French vocabulary words via three classroom exercises that involved retrieving and using their knowledge of French: the exercises occurred back-to-back on the same day or they occurred once per day over three days.

Each lesson was 10 minutes long, so students either completed 30 minutes of exercises in one class session, or 10 minutes of exercises per day over three days. Several days after the lessons were completed, all of the students were given an unexpected test. Contrary to what we might expect, students who completed the exercises across three days performed better than the students who completed the exercises on the same day.^[3] In other words, **even though the two groups of students spent the same amount of time learning the material, the group that spaced out that time over different days learned it significantly better.**



WHY DOES SPACING WORK?

When students encounter information repeatedly in one session, it quickly becomes familiar—what we call an “illusion of knowing.” The English translation for a Spanish vocabulary word readily comes to mind if it was just retrieved moments ago (Zapato - ?). However, **when information is quickly acquired, it’s often quickly forgotten.** Immediate repetition helps students remember something for a short time—i.e., just a few seconds or minutes later—but only because that information is in short-term memory. It can be much more difficult to remember the information after a week, or even a day. Thus, **cramming increases the amount of information in short-term memory, but it does not improve long-term memory.**



Based on a wealth of research, we also know that cramming **feels** easier than spacing, but information learned through cramming is temporary and shallow. In contrast, when learning opportunities are spaced apart, students engage in increased effort to retrieve the information, which improves the durability of learning – what we call a “desirable difficulty.” Similar to why retrieval practice works, when students have to retrieve things from memory and think deeply about what they are learning, they are more likely to remember the information over the long-term.^[4] When using spaced practice, retrieving the information across sessions will not always be easy, and students will have to try harder to remember it. This can lead students to **feel** like they are not learning very well from spaced practice, but that’s precisely why spacing works – the challenge from spacing dramatically improves long-term learning.^[5]

WHAT TYPES OF LEARNING BENEFIT FROM SPACING?

First, spaced practice improves students’ long-term learning of academic knowledge and skills in language, math, science, and social studies.

Students who engage in spaced practice learn the concepts better and also show enhanced understanding—not just memorization—of how the concepts apply to new situations. Being able to apply knowledge to a new situation is known as **transfer** of learning, and is an important goal of education.^[6]

For example, in one study, elementary school children learned scientific information about food chains—such as the tendency for larger animals to eat smaller animals, and the tendency for the number of species to increase when they have more food to eat.^[7] The children received four lessons that involved hands-on demonstrations and questions about the information they were learning. The four lessons occurred on the same day, or once per week across four weeks. The children who received the once-per-week, or “spaced,” lessons learned the information better. On a later test over what they had learned, the spaced group not only performed better on questions over the basic concepts (for example, “Bigger animals typically eat ____ animals”), they also showed greater transfer of learning to new questions (“What does the frog eat?”) and questions that required fairly complex transfer (“Let’s say that all the frogs get captured and taken away by hunters. What happens to the number of turtles? Does it go up, down, or stay the same?”). Thus, spaced practice improves children’s ability to not only retain knowledge they have learned, but also to use that knowledge in different ways.



Second, the benefits of spaced practice last over time.

In one study, middle school students retrieved information from their science lessons either right after the lessons ended, or a few days after the lessons.^[8] On exams given at the end of the semester, students performed better when retrieval practice was spaced a few days after the lessons instead of right afterwards. In another study, middle school students reviewed information from their history class by answering review questions either soon after they learned the material, or several weeks after they learned it.^[9] When both groups were given an unexpected test over the information **nine months later**, the group that reviewed after several weeks scored significantly higher. Maintaining knowledge over the course of a semester, or after a nine-month interval—equivalent to an academic year at many schools—shows that learning information through spaced practice leads to long-lasting and durable knowledge over time.

Third, spaced practice benefits diverse students—from young children learning their first concepts about the world, all the way to medical students learning how to perform surgical operations.

One study found that medical students were more successful in performing a surgery if they had practiced the surgical skills in four spaced sessions that occurred once per week over four weeks, compared to four sessions that occurred on the same day.^[10] To the patient undergoing surgery, the value of spaced practice cannot be overstated!



HOW CAN I IMPLEMENT SPACED PRACTICE?

The good news is, the advantages of spaced practice can be readily obtained, and spaced practice can be implemented in a number of ways. The key to spaced practice is to provide opportunities for students to engage with material they are learning on multiple occasions that are separated in time. This can be done in a number of ways:

Break up lessons into smaller sessions.

Instead of teaching one long lesson over a topic, divide up the lesson into smaller lessons and space them over multiple days. For example, in teaching students to conjugate verbs in a foreign language, conjugation rules can be introduced and practiced in a brief session, followed by additional practice with the same rules on subsequent days. The same goes for any academic material, such as practicing mathematical procedures, practicing to recall terms and definitions, comparing and contrasting different concepts, or generalizing knowledge to new situations.

Revisit concepts that have been taught in previous class meetings.

It is easy for us as teachers to think that once a topic has been “covered,” there is no need to cover it again. To the contrary, students who are learning information for the first time need to revisit it, think about it more, and process it multiple times. Such opportunities can be provided by working into class lessons some of the concepts that had been encountered in previous lessons. These can take the form of class discussions, class activities, or homework assignments that require students to retrieve previously-learned information and relate it to new concepts.

Harness technology to help students set a spaced study schedule.

Students can use a number of accessible online tools—such as online flashcards or electronic calendars—to create and set a schedule with built-in reminders for studying course information. With the help of online course management systems, teachers can also set regular (i.e., daily or weekly) review quizzes and other assignments designed to provide spaced retrieval practice of the concepts being learned.

Include cumulative retrieval practice.

Cumulative quizzes and exams require students to maintain proficiency with information they have learned earlier in the course. Cumulative retrieval practice involves spacing by including concepts learned at earlier points in the course, and it also encourages students to review previously-learned information in order to prepare for the exams. Always make sure to use spacing as a learning strategy throughout the semester or school year, not simply as part of high-stakes assessments.

WHAT ARE POTENTIAL CHALLENGES WHEN IMPLEMENTING SPACED PRACTICE?

Learning through spacing can feel slow and ineffective.

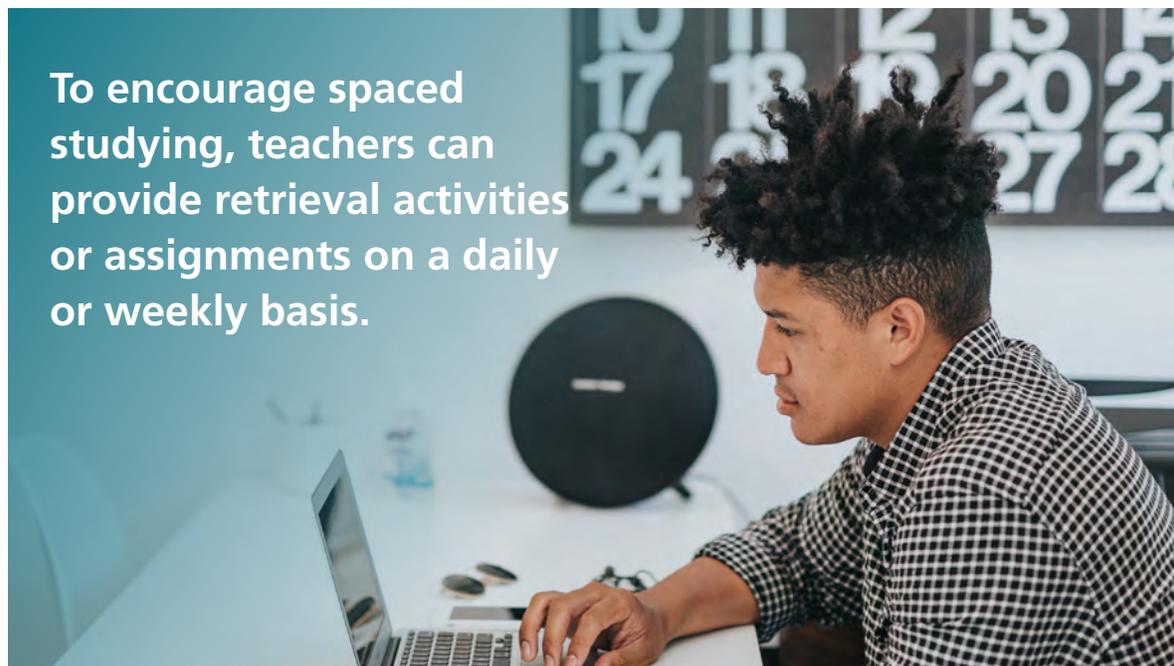
When students try to retrieve information after time has passed, they will notice that they have forgotten some (or even most) of it. This could create a sense of discouragement and the feeling that they are not learning. In reality, however, information that was once learned can be re-learned with less effort, and a spaced schedule allows opportunities to retrieve information after some time has passed in order to see what needs to be re-learned and what is already known, optimizing the use of study time.

Using spacing can require an organized schedule.

Teachers who wish to incorporate spacing into their classes might find it challenging at first to cover smaller portions of information across multiple days, or to incorporate previously-taught concepts into current lessons. Structuring a class to incorporate spaced practice requires some planning. Importantly, however, it does not require major restructuring or overhauls to the course, but rather a redistribution of the same amount of time that will already be spent on each lesson.

Students may not use spaced practice on their own.

Students often opt to study information by cramming a couple of days before the exam. To encourage spaced studying, teachers can provide review activities (e.g., retrieval practice and brief quizzes) or assignments on a daily or weekly basis.





FREQUENTLY ASKED QUESTIONS

How much spacing is enough?

In general, the more, the better. Spaced practice is beneficial whether the lessons occur on consecutive days, one week apart, or even several weeks apart. Research shows that any spacing is better than no spacing, and exactly how much time should occur between learning sessions is less critical. Teachers and learners should strive to space information across multiple days at long enough intervals that encourage challenging retrieval conditions—i.e., “desirable difficulties”—but these intervals can be flexible and adjusted according to course schedules and the specific material being learned.

Should spacing schedules always be the same?

When students learn information across several sessions, should time in-between the sessions increase, decrease, or stay the same? Research shows that slight differences in the timing between sessions does not have a large effect on learning. Students can complete two lessons with one day in-between, with five days in-between, and so on. Compared to learning the information in a single longer session, spacing benefits learning regardless of whether the time between lessons is equal or non-equal.

How should students learn information during spaced practice?

By far the most effective way to learn is to use retrieval practice. When students try to recall information, instead of just reading it, they learn it much better. In particular, repeated attempts to recall information, followed by reviewing the correct answers through informative feedback, are particularly effective for building solid and reliable long-term learning and transfer of knowledge. Although spacing still benefits learning even when students acquire the information purely through reading or listening to a lecture, spacing is even **more** effective when students learn by using retrieval practice.

How many spaced sessions should there be?

Again, the more, the better. For long-term durable learning, teachers and learners should strive to re-visit information over spaced time intervals as many times as possible. The exact number of spacing sessions that can be incorporated, and the time intervals in-between, might depend on the particular course and information being learned. The good news is, spacing benefits learning regardless of how many sessions there are—making it a flexible and adaptive tool that can be tailored to any learning situation—and benefits learning to a greater extent the more it can be utilized.

What should students do in-between spaced learning sessions?

Spacing benefits learning regardless of what students do in-between the spaced sessions. If students practice conjugating verbs in Spanish and then practice the same conjugation rules on a later day, they can engage in any number of activities in-between the two sessions—learning history, science, mathematics, or even conjugation rules in a different language. The key to spacing is to allow time to occur in-between two or more learning sessions, but exactly how that time is spent is less critical. In fact, research has shown that lessons over two or more topics can be alternated, or “interleaved,” to provide spaced practice and also practice at comparing and contrasting the similarities and differences between the content in the two lessons.^[11]



↪ For research, resources, and tips, visit retrievalpractice.org

©2019 The development of this guide was supported by Iowa State University and the James S. McDonnell Foundation Twenty-First Science Initiative in Understanding Human Cognition, collaborative grant 220020483. Any opinions, findings, conclusions, or recommendations expressed are those of the authors and do not reflect the views of Iowa State University or the McDonnell Foundation.



Retrieval Practice

retrievalpractice.org
ask@retrievalpractice.org



@RetrieveLearn



/RetrievalPractice