Study Smarter

Three research-backed strategies

1. Retrieval practice

Retrieval practice means bringing information back to mind from memory, without looking at your notes. Answering a flashcard before flipping it, solving practice questions and writing down everything you remember on a blank page are all forms of retrieval practice.

Rereading and highlighting feel productive because the material looks familiar. Familiarity is a poor signal of what you will remember. Across many controlled studies, students who practised retrieval remembered more on a later test than students who spent the same time restudying (Rowland, 2014). The benefit is largest when you recall from scratch rather than recognise an answer, and when the test comes after a delay.

How to use it:

- Close your notes before you try to answer.
- Check your answer after each attempt. Feedback helps correct errors so they don’t stick (Butler & Roediger, 2008).
- A failed attempt is not wasted. Trying to answer before seeing the answer can improve learning, as long as you then see the correct answer (Kornell, Hays & Bjork, 2009).

2. Spaced practice

Spaced practice means spreading your study sessions over several days instead of concentrating them in one long session. With the same total study time, spaced sessions lead to better long-term retention than cramming (Cepeda et al., 2006).

The longer you need to remember something, the longer the gaps between your sessions can be (Cepeda et al., 2008).

How to use it:

- Example schedule for an exam in two weeks: study the topic on day 1, review it on day 2 or 3, review again around day 7, and do a final review a few days before the exam.
- Start each review with retrieval practice: test yourself first, then reread only what you missed.

Spaced practice answers the question: when do I study?

3. Interleaving

Interleaving means mixing different types of problems or topics within the same study session, instead of practising one type at a time. Practising one type at a time is called blocked practice.

Blocked practice: A A A A, B B B B, C C C C Interleaved practice: A C B B A C B A C

Interleaving works because you must first decide which concept or method applies before you use it. In blocked practice, the chapter title tells you which method to use. On an exam, nobody tells you.

The benefit of interleaving depends on how similar the mixed items are. It has been found for categories that are easy to confuse, such as painting styles by different artists, and for related types of maths problems (Brunmair & Richter, 2019). Interleaving is about mixing related items you need to tell apart. Switching between unrelated subjects, such as accounting and history, is a different practice and is not what these studies tested.

Interleaving often feels harder and slower during practice. In one study, learners rated blocked practice as more effective than interleaving, even after their own test results had shown the opposite (Kornell & Bjork, 2008).

The same idea is used in training. A coach mixes skills in one session rather than repeating one drill for an hour, so you have to read the situation before you act. Practising movement sequences in a random order is slower at first, but gives better retention and transfer than practising them one block at a time (Shea & Morgan, 1979).

Example for a course: instead of all the exercises from Chapter 4 and then all the exercises from Chapter 5, mix exercises from Chapters 3, 4 and 5 in one session. You must work out which idea applies before you start.

Interleaving answers the question: in what order do I practise? Spaced practice (Section 2) answers a different question: when do I study?

4. Common mix-ups

- Spacing and interleaving are two different strategies. Spacing is about the time between study sessions. Interleaving is about the mix of problems within a session. You can combine both.
- Performance during practice is a different thing from learning. Strategies that make practice feel harder can produce better results on later tests (Soderstrom & Bjork, 2015).
- Getting answers from AI during practice can raise practice scores and lower exam scores. In a field experiment with nearly 1,000 high school students, those who practised with a standard GPT-4 chat scored 17% lower on the final exam than students who had no AI access (Bastani et al., 2025).

References

Bastani, H., Bastani, O., Sungu, A., Ge, H., Kabakcı, Ö., & Mariman, R. (2025). Generative AI without guardrails can harm learning: Evidence from high school mathematics. *Proceedings of the National Academy of Sciences, 122*(26). https://doi.org/10.1073/pnas.2422633122

Brunmair, M., & Richter, T. (2019). Similarity matters: A meta-analysis of interleaved learning and its moderators. *Psychological Bulletin, 145*(11), 1029-1052. https://doi.org/10.1037/bul0000209

Butler, A. C., & Roediger, H. L. (2008). Feedback enhances the positive effects and reduces the negative effects of multiple-choice testing. *Memory & Cognition, 36*(3), 604-616. https://doi.org/10.3758/MC.36.3.604

Cepeda, N. J., Pashler, H., Vul, E., Wixted, J. T., & Rohrer, D. (2006). Distributed practice in verbal recall tasks: A review and quantitative synthesis. *Psychological Bulletin, 132*(3), 354-380. https://doi.org/10.1037/0033-2909.132.3.354

Cepeda, N. J., Vul, E., Rohrer, D., Wixted, J. T., & Pashler, H. (2008). Spacing effects in learning: A temporal ridgeline of optimal retention. *Psychological Science, 19*(11), 1095-1102. https://doi.org/10.1111/j.1467-9280.2008.02209.x

Kornell, N., & Bjork, E. L. (2008). Learning concepts and categories: Is spacing the "enemy of induction"? *Psychological Science, 19*(6), 585-592. https://doi.org/10.1111/j.1467-9280.2008.02127.x

Kornell, N., Hays, M. J., & Bjork, E. L. (2009). Unsuccessful retrieval attempts enhance subsequent learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35*(4), 989-998. https://doi.org/10.1037/a0015729

Rowland, C. A. (2014). The effect of testing versus restudy on retention: A meta-analytic review of the testing effect. *Psychological Bulletin, 140*(6), 1432-1463. https://doi.org/10.1037/a0037559

Shea, J. B., & Morgan, R. L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor skill. *Journal of Experimental Psychology: Human Learning and Memory, 5*(2), 179-187. https://doi.org/10.1037/0278-7393.5.2.179

Soderstrom, N. C., & Bjork, E. L. (2015). Learning versus performance: An integrative review. *Perspectives on Psychological Science, 10*(2), 176-199. https://doi.org/10.1177/1745691615569000