Retrieval, interleaving, spacing and visual cues: improving independent learning at scale

Summary of original research by Lukas Feddern, Flavia Schechtmanbelham and Stephen Wilks (Seneca Learning Science team). Published in *Impact*, Issue 2: Science of Learning, The Chartered College of Teaching, February 2018.

1,120	2x+	63%
Year 9 students in a randomised controlled trial	scores vs. revising from printed material	higher scores than the spaced PDF group

Why this study?

Cognitive science points to four strategies that help students remember what they learn: retrieval practice (recalling information rather than rereading it), spacing (spreading study out over time), interleaving (mixing topics and question types) and pairing visuals with text. Yet when students study on their own, they still tend to fall back on passive habits such as rereading and highlighting. The tools that did exist to support better habits usually covered only one or two of these strategies, took a lot of effort to set up, and worked with a narrow range of content.

The Seneca team built a free learning platform that combines all four strategies at once, then ran a trial to test whether it actually improves results compared with more typical ways of revising.

How the platform applies the four techniques

Learning is delivered as a series of short modules that either teach or test a piece of content, using text, images, processes and short questions. An algorithm tracks how each student performs on each item and brings back the material they most need to practise, which creates spacing and interleaving. Each item is tested in one or more question formats to build in retrieval practice, and the same images appear when content is taught and when it is tested, so visuals act as memory cues.

How the trial worked

Students from independent, grammar and comprehensive schools (both single-sex and mixed) took part, studying content from the GCSE Biology Infection and Response unit. They were randomly allocated to one of three groups and all sat a short pre-test first, which confirmed the groups started with very similar prior knowledge. The trial ran in three phases, each two weeks apart, and students worked independently with no help from teachers or peers.

Group	Phases 1 and 2	What it tested
Software	Two 20-minute sessions on the Seneca platform, using a tablet	All four techniques combined
Spacing	Two 20-minute sessions reading a PDF of identical content on a tablet	Controls for spacing and for using a device
Massed practice	Normal lessons in Phase 1, then one 40-minute session with a printed copy in Phase 2	Typical independent revision

In Phase 3 everyone sat the same written post-test (multiple choice, free recall and short answer), marked by an experienced GCSE Biology teacher who did not know which group each student was in. The hypotheses

and analysis plan were pre-registered with the Open Science Framework, and the results were analysed using hierarchical linear modelling to account for students being grouped within schools. Students who missed a phase were excluded.

What they found

Students who used the platform scored more than twice as highly on the post-test as the massed practice group, and 63% higher than the group that read the same content as a spaced PDF. The same pattern held in both selective and non-selective schools. Students in selective schools scored higher overall in every group, but the advantage of the platform was significant in both settings, suggesting it works regardless of school background.

What it means for schools

Combining retrieval, spacing, interleaving and visual cues in one tool appears to make independent study considerably more effective than reading revision material, whether or not that reading is spaced out. Because the platform marks work automatically, it can support homework and revision without adding to teacher workload, and may even reduce it. It is free, needs only an internet-connected device (95% of students in the trial had one) and requires little training for staff or students.

The authors note some open questions: how results hold up over longer-term use and with other subjects, and how much each of the four techniques contributes on its own. The original article was published in 2018, so some terminology reflects understanding at that time.

Read the full research
The complete article, including tables, figures and references, is available from the Chartered College of Teaching:
https://my.chartered.college/impact_article/retrieval-interleaving-spacing-and-visual-cues-as-ways-to-improve-independent-learning-outcomes-at-scale/