

Testing as a tool for learning: ideas for classroom application

Increasingly, findings from cognitive science are informing understanding of how students learn and how we, as teachers, can plan and teach to support more effective learning. In this article I will summarise some research evidence relating to the use of testing as a tool for learning, not just for assessment. I will propose some practical strategies for use in the BEE classroom. I will also suggest ways in which this can inform how we prepare students to revise.

Testing is, of course, a tool for monitoring progress and informing practice through formative and summative assessment. Both students and their teachers need to be able to answer the questions: 'where am I in my learning?', 'where am I going in my learning?' and 'how will I get from where I am to where I'm going?' Testing answers the first of these questions by telling us what the student can do. Analysis of the results of testing can also help to answer the third question by identifying areas of particular strength and weakness so effort is targeted where improvement is needed. What cognitive science now suggests is that testing has impact far beyond these reporting and diagnostic functions: the process of testing, managed appropriately, can actually improve learning.

Retrieval

A test is any activity which requires students to recall or generate information. According to research by, for example, Roediger & Butler (2011) and Bjork & Bjork (2011), testing has impact because it forces students to retrieve information from memory. This act of retrieval is thought to strengthen neural pathways in the brain and improve both speed of later recall and the association of knowledge in one area with related knowledge.

In tests exploring the relative benefits of testing versus studying, effective conditions for testing and the required number of testing events, the following findings were confirmed:

1. Once students have sufficient knowledge of a topic, retrieval practise through testing is more powerful for supporting long-term retention than additional study time;
2. The conditions of retrieval practise matter. Retrieval must be sufficiently challenging to support learning, so the spacing of testing intervals should be large enough to require effort from the student. Spacing should increase over time;
3. *Generation* of answers is more effortful than *recognition* of the correct answer, as in multiple choice questions (MCQs), and should be used to increase challenge where necessary. Varying the conditions of testing is also beneficial: ask students to find different missing variables in formula and to apply their knowledge to a wide range of case study contexts, for example;
4. Testing between 5 and 7 times once knowledge is sufficient seems to be optimal for supporting long-term retention. After this there remains a positive effect of further testing but the size of this effect reduces.

The benefits of retrieval practise are not limited to better recall over time. Other positive consequences identified include: helping students to identify gaps in knowledge; improved transfer of knowledge to new contexts; better organisation of knowledge and monitoring of own learning, and a positive effect on retrieval of related non-tested knowledge.

Feedback

Even where students receive no feedback on whether their answers are correct or incorrect, a positive testing effect has been seen from the act of retrieval. The presence of feedback, however, adds to learning gains and helps to avoid embedding incorrect answers. This is especially important

if using True/False or MCQs as students will be exposed to wrong answers ('lures') which they might otherwise internalise and reproduce.

Research suggests that a powerful way to give feedback is at the end of a period of testing, rather than after individual test / retrieval opportunities (i.e. give all questions on a test, followed by the answers, rather than give the correct answer for each question as you go.)

Application to teaching

So, how can you go about embedding this research into your teaching? One clear implication is the benefit of frequent, low-stakes testing. You could test recall of key terms, formulae or ratios as lesson starters, finish lessons with a 'pop quiz' on the content of the lesson or set tests for homework. As you teach, ask students to make links between the current topic and those learned previously. Move beyond testing the content of just the most recent lesson by including a range of topics at once. You don't need to cover everything – the act of including more varied material raises challenge for students and increases the overall benefit of testing. Test more than simple recall or recognition by asking students to explain and synthesise knowledge within their answers.

Make use of existing materials to encourage retrieval. Most textbooks have end-of-chapter questions which are ready-made tests. Build opportunities into some lessons for students to work through these questions, allowing sufficient time afterwards for feedback, correction of incorrect answers and, ideally, the setting of home study targets to address gaps in knowledge.

When discussing case studies it is easy to build in additional opportunities for retrieval. You might test key terms explicitly or, for greater challenge, ask students to link a particular passage to a piece of previous learning. This helps to develop reasoning as well as embedding learning of content.

Past exam papers are excellent resources for testing. The introduction of new specifications and exam structures doesn't mean that you need to throw away all of your existing resources. MCQs, especially, can be used quickly to engage students develop learning. Why not use one or two at a time to add interest and challenge to a lesson? You can collect whole-class responses using mini whiteboards, or even by having students hold up a number of fingers to correspond with the answer of their choice (1 for A, 2 for B, etc.) Testing doesn't have to take a long time or a lot of preparation!

In fact, you don't even have to write the tests yourself. In class or for homework, you could allocate topics to students and ask them to come up with some questions for their peers. Don't let them forget to write the answers too. These can then become the starter task for the next lesson.

Long term planning

As you plan schemes of work for 2015-16, allow time for introducing students to the learning benefits of testing early in the year. Consider scheduling occasional lessons where students reflect on recent tests and identify gaps in their knowledge – then give them time to study the topics that they need the most. Be on hand to support and to develop the self-study skills needed to support effective revision later in the year.

Supporting revision

Many students (and many teachers!) believe that repeatedly studying known material leads to better learning of it. In support of this, students who 'cram' and then immediately test themselves may well see improved performance in the short term which reinforces their belief in the power of studying / cramming as a revision technique. This cramming (further study of already-known material) works where the test occurs immediately after the studying. But where students are

revising for exams some time in the future, retrieval practise has been shown to have a much more durable and long-lasting impact. As an added benefit, it has also been shown to improve the accuracy with which students judge their knowledge of a topic. So students are less likely to succumb to the false confidence that can result from reading and re-reading a passage to the point where it feels like it is well-known even though it hasn't been tested.

When preparing students for revision you might want to share with them the research findings on retrieval practise. Provide students with lots of materials which they can use to test themselves – past papers, textbooks with end-of-chapter questions and quizzes, and make the answers available too. Feedback doesn't have to come from a teacher, so students can self-mark their answers during revision periods. Encourage students to start their revision of a new topic with a test, using this to direct their study time towards topics which the test shows need more work. Support them to plan revision schedules cyclically so that topics are revisited over time, not as a linear model in which each is addressed only once.

A favourite technique of mine is to give students blank revision diagrams, mind-maps or key word lists which address the contents of a part of the exam specification. Students recall as much as they can and annotate the diagram in detail. This gives a clear visual indication of gaps in knowledge which can then be studied. Later on, students return to their diagrams and recall the missing information, adding it to their work. This works in lessons and also for independent study, once you have 'trained' students in how to approach the exercise.

Conclusions

Testing doesn't have to be onerous and seen as a drain on learning time. Low-stakes testing with time for feedback on results is a learning activity in itself. Testing opportunities are easy to embed in the BEE classroom but can have far reaching consequences, helping students to develop effective strategies for independent learning as well as BEE success!

Attachments

A sample blank mindmap / diagram that I would use with students. This is a poor image, I know. If you'd like a better one for the magazine do let me know and I'll have it scanned and sent over.

References

Bjork, E. L., & Bjork, R. A. (2011) Making things hard on yourself, but in a good way: Creating desirable difficulties to enhance learning. In M. A. Gernsbacher, R. W. Pew, L. M. Hough, & J. R. Pomerantz (Eds.), *Psychology and the real world: Essays illustrating fundamental contributions to society* (pp. 56-64). New York: Worth Publishers. Available online at http://bjorklab.psych.ucla.edu/pubs/EBjork_RBjork_2011.pdf

Francisco, A. & Roediger, H. *Ask the Cognitive Scientist: Retrieval Practice*, available online at <http://www.digitalpromise.org/blog/entry/ask-the-cognitive-scientist-retrieval-practice> [last accessed 27/4/15]

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