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Effective Learning Techniques from Cognitive and Educational Psychology

These are techniques students can use with or without instructor facilitation and without specialized technology. All techniques described below are useful, even “low utility” ones. However, they have been rated according to high, medium and low utility according to whether or not they have been shown to improve student performance across many types of materials, learning conditions, student characteristic and criterion tasks. The traits of each of these categories are outlined below:

Materials	Learning conditions	Student characteristics ^a	Criterion tasks
Vocabulary	Amount of practice (dosage)	Age	Cued recall
Translation equivalents	Open- vs. closed-book practice	Prior domain knowledge	Free recall
Lecture content	Reading vs. listening	Working memory capacity	Recognition
Science definitions	Incidental vs. intentional learning	Verbal ability	Problem solving
Narrative texts	Direct instruction	Interests	Argument development
Expository texts	Discovery learning	Fluid intelligence	Essay writing
Mathematical concepts	Rereading lags ^b	Motivation	Creation of portfolios
Maps	Kind of practice tests ^c	Prior achievement	Achievement tests
Diagrams	Group vs. individual learning	Self-efficacy	Classroom quizzes

^aSome of these characteristics are more state based (e.g., motivation) and some are more trait based (e.g., fluid intelligence); this distinction is relevant to the malleability of each characteristic, but a discussion of this dimension is beyond the scope of this article.

^bLearning condition is specific to rereading.

^cLearning condition is specific to practice testing.

(Dunlosky et al., p. 6)

Techniques for which Research Shows High Utility

Practice Testing, unsurprisingly, involves self-testing or taking practice tests. More than 100 years of research involving hundreds of experiments have shown the effectiveness of students taking practice tests. Students are probably least likely to use this highly useful tool because their experience with testing is of the high-stakes, formal, summative testing variety, an experience one tends to avoid if possible.

The practice testing referred to here is formative testing, typically done outside of class and for which students receive at least right-wrong feedback (ideally guided feedback about what they did wrong, but often they are left to figure this out on their own or from peers). It includes any kind of testing students engage in on their own, including (but not limited to) actual or virtual flash cards, practice problems, questions at the end of textbook chapters, and online practice tests and supporting materials provided by textbook publishers (p. 29).

Recent studies have shown that practice testing can enhance retention by adding further encoding to information in long-term memory. The search for answers activates related information that is further encoded along with the target information, which traces multiple pathways to that information (p. 30).

Also, practice testing may improve students' mental organization of information, as well as how well they process idiosyncratic information (p. 30).

Any format of practice test (e.g., cued recall—student-created flash cards, free recall, short answer, fill-in-the-blank, multiple choice, prediction, procedural practice) improves final test performance, and mismatch between the practice and exam question types doesn't matter. Research suggests that practice tests requiring more generative responses (e.g., recall or short answer) are more effective than fill-in-the-blank or multiple choice recognition ones. And, the more practice testing the better, although time lapse between practice tests is important (p. 31). The effects persist for longer periods than many other methods, especially if correct answer feedback is provided in the practice tests (Pp. 34, 35).

It would be helpful if students were coached on good practice test methods based on the information above.

Distributed Practice is about spreading practice or study activities over time, rather than cramming near the exam deadline. While cramming is better than not studying at all, 254 studies involving more than 14,000 participants show that spaced study is far better (p. 36). Other studies show that the beneficial effects persist in the long term (p.37). Textbooks tend not to encourage distributed practice because they put all related material and practice activities together and do not review previous material in subsequent units (p. 38). Frequent, lower stakes testing during a course will encourage distributed practice far more than having only one or two long, high-stakes exams (Pp. 39-40). Students may need convincing of this technique, seeing it as too much extra work and nothing is ever "finished." However, the high utility effects work across a wide variety of all the materials, learning conditions, student characteristics and learning tasks outlined in the introduction (p. 39).

Techniques for which Research Shows Moderate Utility

Elaborative Interrogation involves generating an explanation for why an explicitly stated fact or concept is true.

A sizeable body of evidence supports the power of explanatory questioning for promoting learning, especially "Why?" questions. The effects are largest when elaborations are precise rather than general; when prior knowledge is higher (pre-existing knowledge helps focus memory on distinctive processing); and when elaborations are self-generated rather than provided (p. 8). Most studies have focused on cued recall, matching, and fact recognition, with mixed results for studies focusing on free-recall tests (p. 10). However, a recent study involving elaborative techniques in an undergraduate introductory Biology course showed a 7% increase in student performance (p.10).

Self-explanation involves students communicating in their own words how new information is related to known information, or explaining steps taken during problem solving. It enhances learning by helping integrate new information with pre-existing knowledge. It works best when no explanations are provided before or during the student generation of self-explanation. Also, self-explanation done during problem solving works better than reflective self-explanation after the problem has been solved (Pp. 11 & 12). Research shows self-explanation works for a wide age range of learners and subjects. Widespread use of this technique is time-consuming.

Interleaved Practice is practice that mixes different kinds of problems or study material within a single study session. The conventional approach is to learn all aspects of one concept, then do practice problems or activities applying that concept, then move on to the next one in a linear fashion. An example of this is to learn the concepts and formula on finding the volume of a particular kind of solid, then solving several problems where you find the volume of that type of solid. After that, students move on to the concepts and formula for finding the volume of a different type of solid and do several practice problems for that type. This continues for four types of solids (in our example).

An interleaved practice approach would be to work through the material on finding the volume for all four types of solids, then doing the practice problems in a rotating order—that is, each set of four problems would have one problem for each type of the four solids.

A study that compared these two methods showed a 43% increase in accuracy for the interleaved approach (p. 40). Other research has produced positive results, but there has not been the high volume of research done on this method compared to practice testing and distributed practice, so this method goes in the moderate utility category. Also, research tends to indicate that the greatest benefit of interleaved practice is experienced by students at the lower end of knowledge of the discipline (p. 42).

Interleaved practice helps students put the big picture together better (while discriminating effectively between different concepts), because they see things repeatedly in relationship to one another. Also, interleaved practice does more short-term memory encoding of mental schema because material has to be frequently recalled from long term memory to solve similar but different problems. In contrast, in the linear approach, all the problem solving is done while all the information for that one concept is in short term memory, from which it is stored in long term memory and not recalled or used again until test time, and the next linear component is mastered independently. Research also suggests that interleaved practice works best when there is a significant amount of instruction and practice on one concept before moving on to another, and that practice on the second concept is interleaved with the first by integrating aspects of the first concept in the practice on the second (p. 44).

Techniques for which Research Shows Low Utility

Summarization, predictably, involves writing summaries of material being learned. The point is to identify the important ideas and say how they connect to each other, while omitting the unimportant and repetitive. Studies have shown that writing important points in one's own words is more effective than just identifying important information, so summarization is better than highlighting or rereading (Pp. 15 and 18). The main reason for the "low utility" rating is that summarization covers so broad a range of strategies (e.g., words, sentences, paragraphs, limited in length and not, capture an entire reading or portions of it, written or spoken) that comparing findings is difficult. And, summarization effectiveness may vary according to reading and writing ability; readability of the text; the nature of the material; and the level of pre-existing knowledge.

Research does show that summarization is particularly beneficial to undergraduate students (p. 16). It helps with learning tasks at the application and analysis levels of learning (p. 17). Most research has focused on summarization improving retention of factual details or comprehension, and the effect

persists for days or weeks (p. 17). The technique takes little training for students to use, unless they have had little previous exposure to summarization, in which case practice of the technique itself is needed for summarization to be effective.

Highlighting involves students marking what they consider to be important parts of material being learned while reading, typically by underlining or using a coloured marker. Active highlighting helps student performance more than passive highlighting (someone else has highlighted what the students read). This probably indicates that actively choosing what is important involves extra mental processing that is beneficial. The less text highlighted the better (e.g., one sentence per paragraph rather than many). The quality of the highlighting matters—that is, did students highlight the most important material? Students may need direction and practice doing so if they have not had much previous experience; otherwise highlighting requires no training, which is why it is so popular with students. It also likely is popular because it takes little extra time beyond what would have been spent reading the text otherwise. Highlighting tends to work best (when it does work) for factual recall and disadvantage highlighters on inference test questions (p. 20).

Undergraduate students tend to over-mark text, which may be why so many studies show no test score improvement from highlighting. Lack of test score improvement is why this technique has been relegated to the “low utility” category.

The **Keyword Mnemonics** techniques that the authors investigated was said to involve using key words and mental imagery to associate verbal materials. However, the research reviewed deals only with “keyword” *mental* imagery, and I can’t distinguish it from Imagery Use for Text Learning (below), other than the “keyword” aspect of the mental image pertains to a mental picture of a single word item—e.g., a tooth for “la dent” to remember the English word is “tooth” and dent is part of the word “dentist;” or a cliff for “le clef,” or key. I was expecting ROY G BIV for the colours of the rainbow, or “Every Good Boy Deserves Fudge” for EGBDF, the lines on the treble clef in music. Many others do as well, judging from a quick look online. Ultimately, it doesn’t really matter much—research is so mixed that there is doubt about keyword mnemonic effectiveness, except for a narrow range of “keyword-friendly content” areas such as second language acquisition.

Imagery Use for Text Learning involves attempting to form mental images of text materials while reading or listening. Imagery works better with listening; reading while trying to visualize tends to negate the benefit (p. 26), probably due to the overtaxing of short-term memory resources. This technique works for easy-to-imagine text material and spatial descriptions, but not for abstract texts. Also, research indicates that mental imagery works in the lower-level recall learning tasks but not at higher levels, such as understanding, application or making inferences. Not much research has been done to determine how long lasting the beneficial effects are, when they do occur (p. 26).

Rereading refers to restudying text materials after the initial reading. Research indicates that it helps with higher-level processing (reproducing the main ideas) rather than details, and the beneficial effects are greater if the rereading is “spaced”—that is, it occurs a week or two after the initial reading. Longer gaps tend to have diminished rereading benefits (p. 27). Also, the highest benefit comes from a single

re-reading, rather than multiple ones, and rereading effects withstand spaced rereading of several texts during the same time period. Rereading effects seem to work for both high and low prior knowledge readers and across a wide variety of content types (p.28).

Most students (even high achievers) report rereading and highlighting, but these methods do not consistently improve student performance as much as most other methods (e.g., direct explanation and practice testing rather than re-reading) (Pp. 5, 29).

Reference

Dunlosky, J.; Rawson, K. A.; Marsh, E. J.; Nathan, M. J.; & Willingham, D. T. (2013). Improving Students' Learning With Effective Learning Techniques: Promising Directions from *Cognitive and Educational Psychology*, in *Psychological Science in the Public Interest*, 14(1), 4-58.