Improving Students' Learning with Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology

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In this monograph, 10 learning techniques are discussed in detail and recommendations about their relative utility are offered. The techniques are as follows: elaborative interrogation, self-explanation, summarisation, highlighting (or underlining), keyword mnemonics, imagery use for text learning, rereading, practice testing, distributed practice, and interleaved practice.

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Many students are being left behind by an educational system that some people believe is in crisis. In this monograph, 10

learning techniques are discussed in detail and recommendations about their relative utility are offered. The techniques are elaborative interrogation, self-explanation, summarisation, highlighting (or underlining), keyword mnemonics, imagery use for text learning, rereading, practice testing, distributed practice, and interleaved practice. To offer recommendations about the relative utility of these techniques, it was evaluated whether their benefits generalise across four categories of variables: learning conditions, student characteristics, materials, and criterion tasks.

- Simple techniques are available that teachers and students can use to improve student learning and achievement. Hence, it is surprising that teachers have not been told about these techniques and many students are not using them.
- Some effective techniques are underutilised because teachers do not learn about them (hence students do not use them). This is despite evidence suggesting that the techniques could benefit student achievement with little added effort.
- Some learning techniques that are popular and often used by students are relatively ineffective.
- Some techniques (such as self-testing and distributed practice) have been chosen for this study because an initial survey of the literature indicated they could improve student success across a wide range of conditions.
- Some techniques (such as rereading and highlighting) were included in the study because students report using them frequently.
- The choices were limited to techniques that could be implemented by students without assistance.
- The review of each learning technique describes how it can be used, its effectiveness for producing long-term retention and comprehension, and its breadth of efficacy across the categories of listed variables (materials,

learning conditions, student characteristics, and criterion tasks).

Learning techniques:

1. Elaborative interrogation
    - Generating an explanation for why an explicitly stated fact or concept is true
2. Self-explanation
    - Explaining how new information is related to known information or explaining steps taken during problem solving
3. Summarisation
    - Writing summaries (of various lengths) of to-be-learned texts
4. Highlighting/underlining
    - Marking potentially important portions of to-be-learned materials while reading
5. Keyword mnemonics
    - Using keywords and mental imagery to associate verbal materials
6. Imagery for text
    - Attempting to form mental images of text materials while reading or listening
7. Rereading
    - Restudying text material after an initial reading
8. Practice testing
    - Self-testing or taking practice tests on to-be-learned

material

9. Distributed practice

- Implementing a schedule of practice that spreads study activities over time

10. Interleaved practice

- Implementing a schedule of practice that mixes different kinds of problems, or a schedule of study that mixes different kinds of material within in a single study session

Evaluation of the learning techniques

- Each technique is assessed in terms of its relative utility: low, moderate, or high
- Although a technique could be designated low utility because its effects are limited to a small subset of materials that students need to learn, it could be useful in some cases and adopted in appropriate contexts. However, relative to the other techniques, it would be considered low in utility because of its limited generalisability.
- A technique could receive a low or moderate utility rating if it showed promise but lacked sufficient evidence to support confidence in assigning a higher utility assessment.

Elaborative interrogation

What it is and why it should work?

- Prompting students to answer ‘Why?’ questions can facilitate learning.
- Average effect sizes range from 0.85 to 2.57.
- The key to elaborative interrogation involves prompting learners to generate an explanation for an explicitly

stated fact.
- Elaborative interrogation enhances learning by supporting the integration of new information with prior knowledge.
- Processing of similarities and differences among to-be-learned facts also accounts for findings that elaborative-interrogation effects are often larger when elaborations are precise rather than imprecise, when prior knowledge is higher rather than lower, and when elaborations are self-generated rather than provided.

How general are the effects?

- Elaborative-interrogation effects have been consistently demonstrated using either incidental or intentional learning instructions.
- Although most studies have involved individual learning, elaborative-interrogation effects have also been exhibited among students working in dyads or small groups.
- Elaborative-interrogation effects appear to be relatively robust across different kinds of learners, although the extent to which elaborative interrogation benefits younger learners is less clear.
- Prior knowledge is an important moderator of elaborative-interrogation effects, with effects generally increasing as prior knowledge increases.
- Elaborative-interrogation effects are relatively robust across factual material of different types and with different content.

Issues for implementation

- The apparent requirement of minimal training is a possible merit of elaborative interrogation.
- Elaborative interrogation appears to be relatively reasonable with respect to time demands.
- A limitation of elaborative interrogation concerns its

potentially narrow applicability to discrete factual statements.
- Elaborative interrogation is rated as having moderate utility.

Self-explanation

What it is and why it should work?

- The core component of self-explanation involves students explaining an aspect of their processing during learning, such as by asking themselves ‘What does the statement mean?’ or ‘Is there anything I still don’t understand?’.
- Self-explanation can enhance learning by supporting the integration of new information with prior knowledge.

How general are the effects?

- Self-explanation has been found effective when accompanied by either direct instruction or discovery learning.
- Self-explanation effects have been exhibited by with both younger and older learners.
- One of the strengths of self-explanation literature is that effects have been shown across different materials within a task domain and across several different task domains.
- Self-explanation has been shown to support many kinds of logic puzzles and mathematics problems, has helped younger learners to overcome various kinds of misconceptions, and has improved their understanding of false belief, number conservation, and principles of balance.
- Self-explanation appears to be broadly applicable.
- Studies involving text learning have also shown the effects of self-explanation on measures of comprehension.

- Studies have shown self-explanation effects on near-transfer tests, in which students are asked to solve problems that have the same (but not identical) structure as practice problems.
- Self-explanation effects on far-transfer tests have been demonstrated for the solving of mathematics problems and pattern learning.

Issues for implementation

- A particular strength of the self-explanation strategy is its broad applicability across a range of tasks and content domains.
- Most students can profit from self-explanation with minimal training.
- Some students may require more instruction to implement self-explanation successfully. Thus, the benefit of self-explanation might be enhanced by teaching students how to implement the self-explanation technique effectively.
- Self-explanation was rated as having moderate utility.

Summarisation

What it is and why it should work?

- Successful summaries identify the main points of a text and capture its essence while excluding unimportant or repetitive material.
- More than just facilitating the extraction of meaning, summarisation should also boost organisational processing. This is because extracting the gist of a text requires learners to connect disparate pieces of the text instead of simply evaluating its individual components.
- Writing about the important points in one’s own words produces a benefit over and above that of selecting important information.

- Summarisation appears to benefit students.
- Higher-quality summaries that contain more information and are linked to prior knowledge are associated with better performance.

How general are the effects?

- Younger students struggle to identify main ideas and tend to write lower-quality summaries that retain more of the original wording and structure of the text. However, younger students (such as middle school students) can benefit from summarisation following extensive training.
- When summarisation increases performance, its effects are relatively robust over days or weeks.
- While benefits can be observed in classroom settings, the real constraint is whether students have the skill to successfully summarise—not whether summarisation occurs in the lab or classroom.

Issues for implementation

- Summarisation would be feasible for undergraduates or other learners who already know how to summarise. For these students, summarisation would constitute an easy-to-implement technique that would be quick to complete or understand.
- Implementing the strategy with students who are not skilled summarisers would be a difficult issue.
- Instructors might want students to summarise material because summarisation itself is a goal, not because they plan to use summarisation as a study technique. Moreover, this goal may merit the efforts of training.
- Summarisation is rated as low utility.
- While summarisation can be an effective learning strategy for learners who are already skilled at summarising, many learners (including children, high school students, and even some undergraduates) will

require extensive training. This renders the strategy less feasible.

Highlighting and underlining

What it is and why it should work?

- Highlighting and underlining typically appeal to students because they are simple to use, do not entail training, and do not require students to invest much time beyond that already required for reading the material.
- Reading marked text promotes subsequent memory of the marked material.
- Actively selecting information should benefit memory more than simply reading marked text.
- While marked text draws reader attention, additional processing should be required if the reader has to decide which material is most important. Such decisions require the reader to think about the meaning of the text and how its different pieces relate to each other.
- The quality of the highlighting is probably crucial to whether it helps students to learn.

How general are the effects?

- Prior knowledge might moderate the effectiveness of highlighting.
- Mainly in the studies reviewed, it was determined that highlighting did not improve learning.

Issues for implementation

- Given students' enthusiasm for highlighting and underlining, discovering fail-proof ways of ensuring this technique is used effectively might be easier than convincing students to abandon it entirely in favour of other techniques.
- Highlighting and underlining is rated to have low

utility.
- It can help when students have the knowledge needed to highlight more effectively or when texts are difficult. However, highlighting can actually hurt performance on higher-level tasks that require inference making.

Keyword mnemonics

What it is and why it should work?

- Keyword mnemonics is a technique based on interactive imagery developed by Atkinson and Raugh (1975).
- As an example, Keyword mnemonics can be used for learning foreign vocabulary.
- Interactive imagery involves elaboration that integrates the words meaningfully. Moreover, the images themselves should help to distinguish the sought-after translation from other candidates.

How general are the effects?

- The benefits of keyword mnemonics can be generalised to many different kinds of material: a) foreign-language vocabulary, b) the definitions of obscure vocabulary terms and science terms, c) state-capital associations, d) medical terminology, e) people's names and accomplishments or occupations, and f) minerals and their attributes.
- Keyword mnemonics have also been shown to benefit learners of different ages (from Grade 2 to college level) and students with learning disabilities.
- The outcomes of implementing keyword mnemonics in classroom settings have been mixed.

Issues for implementation

- The majority of research on keyword mnemonics has involved at least some training, which has predominantly been aimed at helping students develop interactive

images and use them for subsequently retrieving targets.
- Beyond training, implementation also requires the development of keywords, whether by students, teachers, or textbook designers.
- Keyword mnemonics is rated as low utility.
- While keyword mnemonics show promise for keyword-friendly materials, it is not highly efficient and may not produce durable learning.

Imagery use for text learning

What it is and why it should work?

- When students read text, they imagine the content of each paragraph using simple and clear mental images.
- Developing images can enhance one's mental organisation or integration of information in the text. Moreover, idiosyncratic images of particular referents in the text could also enhance learning.
- Using prior knowledge to generate a coherent representation of a narrative may enhance a student's general understanding of the text.
- The literature review suggests that the effects of using mental imagery to learn from text may be rather limited and not robust.

How general are the effects?

- Imagery has more benefits among students who have listened to texts compared to students who have read them.
- In some studies, students' spontaneous use of imagery in control conditions was deemed partly responsible for the failure of imagery to benefit performance in some cases. However, this has not been quantified.
- Despite the promise of imagery, the patchwork of inconsistent effects for Grade 4 students has been

replicated with students of other ages.

- While Grade 3 students have been shown to benefit from using imagery, younger students do not appear to benefit from attempting to generate mental images when listening to a story.
- Although imagery instructions can boost performance, sometimes they have no effect.
- In general, imagery instructions do not tend to enhance students' understanding or application of the content of a text.

Issues for implementation

- The majority of studies have examined the influence of imagery by using relatively brief instructions that encouraged students to generate images of text content while studying.
- Imagery can improve students' learning of text materials and imagery production and is more broadly applicable than keyword mnemonics.
- The benefits of imagery are largely constrained to imagery-friendly materials and memory tests.
- The use of imagery for learning text is rated as low utility.

Rereading

What it is and why it should work?

- Rereading is one of the techniques that students most frequently report using during self-regulated study.
- According to the quantitative hypothesis, rereading simply increases the total amount of information encoded, regardless of the kind or level of information within the text.
- The qualitative hypothesis assumes that rereading affects the processing of higher- and lower-level information within a text differently, with particular

emphasis placed on the conceptual organisation and processing of main ideas during rereading.
- Evidence appears to favour the qualitative hypothesis.

How general are the effects?

- The effects of rereading are fairly robust across other variations of learning conditions.
- The lag between initial reading and rereading is an aspect of the learning conditions that significantly moderates the effects of rereading.
- Although the advantages of rereading have been demonstrated with massed and spaced rereading (in which some amount of time passes or intervening material is presented between initial study and restudy), spaced rereading usually outperforms massed rereading.
- Spaced rereading appears to be effective across moderate lags, with studies reporting significant effects after lags of several minutes, 15-30 minutes, 2 days, and 1 week.
- Most of the benefits of rereading over a single reading appear to accrue from the second reading. Moreover, the majority of studies involving two levels of rereading have indicated diminishing returns from additional rereading trials.
- Most studies on rereading effects have involved undergraduate students.
- Rereading effects are robust across variations in the length and content of text material.

Issues for implementation

- One advantage of rereading is that students require no training, other than perhaps being instructed that it is generally most effective when completed after a moderate delay rather than immediately after an initial reading.
- Relative to some other learning techniques, rereading is relatively economical with respect to time demands.

- Direct comparisons of rereading to other techniques (such as elaborative interrogation, self-explanation, and practice testing) have consistently shown rereading to be an inferior technique for promoting learning.
- Rereading is rated as having low utility.

Practice testing

What it is and why it should work?

- Testing is viewed by many students as an undesirable necessity of education. This is unfortunate because it overshadows the fact that testing also improves learning.
- The century of research on practice testing demonstrates the broad generalisability of the benefits of practice testing.
- Testing can enhance retention by triggering elaborative retrieval processes. Attempting to retrieve target information involves a search of long-term memory that activates related information. Further, this activated information may then be encoded along with the retrieved target, forming an elaborated trace that affords multiple pathways to facilitate subsequent access to that information.
- Practice testing may enhance how well students mentally organise information and how well they process idiosyncratic aspects of individual items. Together, these can support better retention and test performance.

How general are the effects?

- Practice tests can benefit learning even when their format does not match the format of the criterion test.
- Practice tests that require more generative responses (such as recall or short answer) are more effective than practice tests that require less generative responses (such as filling in the blank or recognition).

- Concerning dosage, more is better.
- Concerning time intervals, longer is better.
- Repeated practice testing produces greater benefits when lags between trials within a session are longer rather than shorter, when trials are completed in different practice sessions rather than all in the same session, and when intervals between practice sessions are longer rather than shorter.
- The testing effects have been demonstrated across participants with a wide variety of ages.
- Some form of testing effect has been demonstrated with preschool and kindergarten children, elementary school students, middle school students, high school students, more advanced students, middle-aged learners, and older adults.

Issues for implementation

- Practice testing appears to be relatively reasonable with respect to time demands.
- Practice testing can be implemented with minimal training.
- The advantage of practice testing with feedback over restudy is it is extremely robust.
- The implementation of feedback with practice testing protects against perseveration errors when students respond incorrectly.
- Several studies have reported positive outcomes from administering summative assessments that are shorter and more frequent rather than longer and less frequent. This is true for both learning outcomes and student ratings of factors (such as course satisfaction and preference for more frequent testing).
- Practice testing is rated as having high utility.

Distributed practice

What it is and why it should work?

- The term distributed practice effect refers to the finding that distributing learning over time (either within a single study session or across sessions) typically benefits long-term retention more than amassing learning opportunities back-to-back or in relatively close succession.
- One theory invokes the idea of deficient processing, arguing that processing material during a second learning opportunity suffers when it is temporally close to the original learning episode. Students do not have to work very hard to reread notes or retrieve something from memory when they have just completed this same activity. Furthermore, they may be misled by the ease of this second task and think they know the material better than actuality.
- Another theory involves reminding. Here, the second presentation of to-be-learned material serves as a reminder to the learner of the first learning opportunity, leading it to be retrieved. This process is known to enhance memory.
- Some researchers draw on consolidation in their explanations, positing that the second learning episode benefits from any consolidation of the first trace that has already happened.

How general are the effects?

- The distributed-practice effect refers to improved learning when learning episodes are spread out temporally rather than when they occur in close succession.
- In general, distributed practice testing is superior to distributed study.
- While the majority of distributed-practice experiments have tested undergraduates, effects have also been demonstrated in other populations.
- In general, children of all ages benefit from

distributed study.
- Even children aged two years show benefits of distributed practice, such that it increases their subsequent ability to produce studied words. These benefits of spacing for language learning also occur for children with specific language impairments.
- Distributed-practice effects have been observed with many types of to-be-learned materials.
- A number of classroom studies have examined the benefits of distributed practice tests.

Issues for implementation

- One issue students face is that study materials may not be set up in a way that encourages distributed practice.
- Students naturally study in a procrastination scallop way, meaning that time spent studying increases as exams approach.
- Less frequent testing may result in massed study immediately before a test, whereas daily testing effectively leads to study that is distributed over time.
- Students may need some training and convincing that distributed practice is a good way to learn and retain information.
- While simply experiencing the distributed-practice effect may not always be sufficient, a demonstration paired with instruction about the effect may be more convincing to students.
- Distributed practice is rated as having high utility.

Interleaved practice

What it is and why it should work?

- In interleaved practice, students alternate their practice of different types of items or problems. In contrast, blocking practice requires that all content

from one subtopic is studied (or all problems of one type are practiced) before the student progresses to the next set of material.
- During practice, performance was better with blocked practice compared to interleaved practice. However, this advantage dramatically reversed on the criterion test.
- One explanation for the impressive effect of interleaved practice is that interleaving gives students practice at identifying which solution method should be used for a given item or problem.
- Interleaved practice helps students to discriminate between the different kinds of problems, meaning they will be more likely to use the correct solution method for each one.

How general are the effects?

- Interleaved practice may further enhance a student's ability to develop accurate concepts when exemplars of different concepts are presented simultaneously.
- Interleaved practice may only be most beneficial after a certain level of competency has been achieved using blocked practice with an individual concept or problem type.
- The majority of studies on interleaved practice have included college-aged students. Sometimes performance was improved and sometimes there was no effect.
- It seems plausible that motivated students could easily use interleaving without help.

Issues for implementation

- After a given type of problem (or topic) has been introduced, practice should first focus on that particular problem. After the next type of problem is introduced (such as during another lecture or study session), that problem should first be practiced. However, this should be followed by extra practice

involving interleaving the current type of problem with others introduced during previous sessions.
- Interleaved practice may take more time to implement compared to blocked practice, because solution times often lengthen during interleaved practice. However, slowing down probably indicates the recruitment of other processes that boost performance.
- Interleaved practice is rated as having moderate utility.
- Interleaved practice has been shown to have a relatively dramatic effect on student learning and the retention of mathematical skills.
- Interleaving helps with other cognitive skills.

Relative utility of the learning techniques

- Although easy-to-use assessments of each learning technique are provided, it is encouraged that interested teachers and students carefully read each review to make informed decisions about which techniques will best meet their instructional and learning goals.

High utility techniques

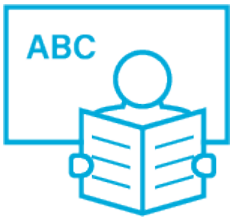
- Practice testing
- Distributed practice

Moderate utility techniques

- Elaborative interrogation
- Self-explanation
- Interleaved practice

Low utility techniques

- Summarisation
- Highlighting
- Keyword mnemonics
- Imagery use for text learning
- Rereading



Implications

- Beyond training students to use these techniques, teachers could also incorporate some of them into their lesson plans.
    - When beginning a new section of a unit, a teacher could begin with a practice test (with feedback) on the most important ideas from the previous section.
    - When students are practicing problems from a unit on mathematics, recently studied problems could be interleaved with related problems from previous units.
    - Teachers could also harness distributed practice by re-presenting the most important concepts and activities over the course of several classes.
    - When introducing key concepts or facts in class, teachers could engage students in explanatory questioning by prompting them to consider how the information is new to them, how it relates to what they already know, or why it might be true.
    - Even homework assignments could be designed to take advantage of many of these techniques.
- Teachers should be encouraged to train students to use learning techniques more consistently (and explicitly) when they are engaged in pursuing various instructional and learning goals.