Brain-Friendly Learning Tips for Long-Term Retention and Recall

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The main study skills students presently rely on are massed practice, repetition, rereading, and highlighting which cause a false sense of fluency (Bjork & Bjork, 1992). Memory has two strengths, storage strength and retrieval strength, with the theory of desirable difficulty stating that the harder one has to work to retrieve a memory, the greater the subsequent spike in retrieval and storage strength (Bjork & Bjork, 1992; Hattie, 2013). Spaced repetition, pretesting, interleaving, and regular testing are a few study skills that can lead to deeper learning. Incorporating them into teaching as well as showing students how to use them could lead to deeper learning, stronger retrieval, and longer retention. This paper examines these study skills, including examples of how to incorporate them into various classroom activities.

学習者の主な学習スキルは、集中練習、反復、再読、蛍光ペンなどでマークすることだが、これらは学習者が流暢だと思い込む要因となり得る (Bjork & Bjork, 1992)。記憶力には「保持」と「想起」の2つがあり、「望ましい困難」は、記憶を想起する為に努力すればするほど、結果的に保持と記憶力が増加するという理論である(Bjork & Bjork, 1992; Hattie, 2013)。Spaced repetition (間隔反復)、Pretesting (事前 (予備) 試験)、Interleaving(インターリーブ：交互配置)、定期試験は、より深い学びに至る学習スキルである。これらのスキルを授業に取り入れ、スキルの使い方を教えることは、より深い学習と学習者の達成感につながるだろう。本論文では、これらの学習スキルをどのように教室の授業活動に盛り込めるかについて具体的に検討する。

Learning is a process that leads to change as a result of our experiences, increasing the potential for enhanced outcomes and improved future learning (Amrose, Bridges, DiPietro, Lovett, & Norman, 2010). Making changes in the brain requires creating new connections, building upon background knowledge, encountering new information in various formats, and even forgetting. The brain needs to encounter new information many times, relearning it in order to retain the new information in long-term memory. For most students, the typical way to prepare for an exam or new learning is through cramming or mass-practice. Unfortunately, this practice leaves students with a lack of or poor prior knowledge. When prior knowledge is weak or insufficient, it cannot support new knowledge (Amrose et al., 2010), requiring students to constantly struggle with new learning and retention. Helping students overcome their weaknesses and improve requires them to learn new methods or techniques for retaining new information and strengthening their prior knowledge.

Unfortunately, students believe mass-practice works because they witness a quick improvement in the ability to recall information. This false sense of fluency (Bjork & Bjork, 1992) plateaus and quickly disappears resulting in being unable to recall the information during the exam or later in other courses. Students feel that because the facts, formulas, or arguments were easily remembered during practice, they should remain that way forever. What students don't realize is that the harder one has to work to retrieve a memory, the greater the subsequent spike in retrieval and storage strength. This is known as desirable difficulty (Bjork & Bjork, 1992). They found that storage strength is a measure of how well something is learned which builds up steadily with study and use and can increase but never decreases.

In this paper we demonstrate that despite the popularity of quick fix solutions like the mass-practice approach to learning, spaced repetition, pretesting, regular testing, and interleaving are better ways to learn to overcome the inevitable plateau and the false sense of fluency. While these approaches might produce a slower rate of improvement in the beginning, they lead to a greater accumulation of learning over time, as will be discussed in the article.

Spaced Repetition

An example of Bjork and Bjork's (1992) term *desirable difficulty* could be the multiplication tables many children learn in math class. They acquire accuracy through the combination of steady studying accompanied by ample opportunities to demonstrate use of that knowledge. Retrieval strength, on the other hand, is a measure of how quickly or easily one can recall information. This also increas-

es with study and use, but will decrease over time, hence the need for constant review. The principle of mass-practice relies on short-term memory, whereas durable learning requires time for mental rehearsal and the other processes of consolidation to take effect, including forgetting. Forgetting aids learning by actively filtering out competing facts, and additional practice allows for deeper learning (Bjork & Bjork, 1992). For this reason, spaced repetition increases the effort required to retrieve new learning, re-triggering consolidation, and further strengthening memory (Roediger & Karpicke, 2006). Roediger and Karpicke (2006) found that when one successfully recalls information through spaced repetition, he (a) restores the information differently than how it was previously stored; (b) develops new connections to the information, such as connections relating to other facts in mind at the time of recall; and (c) alters the old network of cells which previously stored the information.

How Spaced Repetition Works in an EFL Environment

Sebastian Leitner in the 1970s developed the Leitner Box (Landauer & Bjork, 1978). Using five boxes, four boxes for spaced practice—one box for frequent (daily) study, the second box every three days, the third box once a week and the fourth every month, vocabulary cards move in either direction between the boxes as they are studied (see Figure 1). On the first day, the student studies and moves words he knows into the second box. Daily, the student goes through this process until the fourth day when the student studies both the first and second boxes (see Figure 2). The second box of words has not been reviewed for four days, creating the desirable difficulty effect when reviewed. If the student successfully recalls a word it moves into the third box, where it stays until the following week. If the student does not recall the word correctly from box number two, it moves back to box number one and is studied daily again. This process continues until words move into box number five where they are reviewed every other month. It is at this point that the words have a strong storage and retrieval strength, becoming part of one's long-term memory.

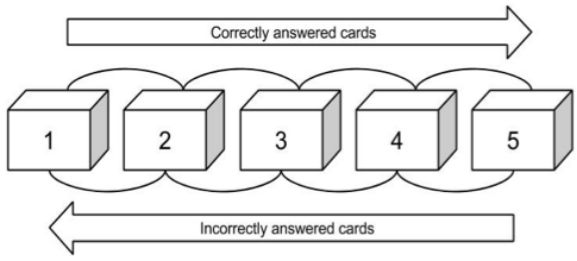

Figure 1. **Demonstration of Leitner's box for vocabulary study.**

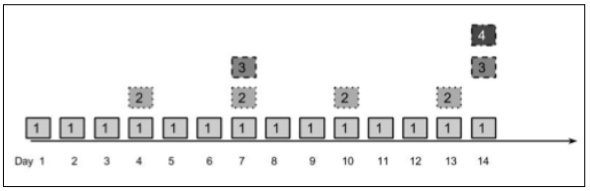

Figure 2. **Demonstration of vocabulary card box study intervals.**

Pretesting

Pretesting is the method of testing students on information which has not yet explicitly been taught or studied. The brain is stimulated by novelty, paying close attention to it and later, when the brain encounters the item again, it recalls the first encounter (Brown, Roediger, & McDaniel, 2014; Sousa, 2011; Willis, 2006). Essentially, pretesting is developing background so two or three classes later, when the material is presented, there is a higher possibility of making a connection and being retained.

Additionally, pretesting requires students to work harder by guessing first rather than by studying directly, eliminating the fluency illusion (Bjork & Soderstrom, 2015; Roediger & Karpicke, 2006a; 2006b). With mass-practice or memorizing, students only study the correct answer. Pretesting offers additional choices, hence throwing the student off so he does not second-guess himself on the test. For example, a student studies the capital of Australia as Canberra but on the test encounters additional options such as Sydney, Melbourne, or Brisbane. Suddenly, he second-guesses himself and may choose incorrectly. One element to keep in mind with pretesting is that it requires immediate feedback, so any pretest must be corrected immediately. Immediate, corrective feedback helps prevent students from incorrectly retaining material they have misunderstood and produces better learning of the correct answers.

How Pretesting Works in an EFL Environment

Pretesting cannot be used with students who do not possess basic language abilities. For example, if the students are zero beginners and do not know the English alphabet, pretesting will not work because students will be unable to comprehend what is

written. Multiple choice tests work best considering the principle idea is to prime the student's brain for what is coming.

A quick and easy way to design and administer these tests is by using Pear Deck (www.peardeck.com), a free program that allows students to use their mobile phones as clickers and stores the data for the teacher to review later. For example, the content to be tested could be relative clause pronouns. Before class, the teacher creates the questions using Pear Deck and during class posts them on the screen (see Table 1).

Table 1. Example Question Shown to Students.

Q. #1) I saw a man (_____) was sitting on a bench.
a. what
b. who
c. which
d. where

Students are able to follow along by looking at their mobile phones which mirror what is being shown on the screen. Since the teachers have access to real-time data, they can review the student's answers and give feedback accordingly. The teacher can also make sure students move along efficiently and time is not wasted. Using Pear Deck for pretesting at the beginning of class should encourage students to arrive on time as well as eliminate the need to take attendance since Pear Deck keeps a record when the student logs on. A few other pretesting ideas that could be used for vocabulary practice can be seen in Appendices A-C.

Interleaving

Interleaving is the idea of presenting learning in different contexts for stronger memories, essentially, mixing-up the learning. When a person interleaves, he is surrounding the new material or skill with older knowledge or skills, possibly materials he already knows but has not revisited in a while, whereas repeated practice on one skill slows learning down (Taylor & Rohrer, 2010). Wang and Aamodt (2011) described interleaving using the example of two baseball players. Player one practiced hitting only fastballs followed by curve balls followed by sliders. Player two practiced by mixing up the pitches without knowing which pitch was coming. So, a fastball would be followed by a curveball or slider, then followed by a different pitch and so on. After a period of practice, the players were tested to see who could hit the most pitches. Research showed player two did much better than player one (Hall, Domingues, & Cavazos, 1994). Mixing up the pitches during practice helped player two distinguish differences between the different pitches, enabling him to hit more balls than player one. The brain learns to quickly determine incongruities, in essence when the brain sees something that is out of order or out of place, it wakes up. Taylor and Rohrer (2010) determined that interleaving enables better discrimination and produces better scores on later tests because by mixing up learning between new and old material, one is better able to recognize old material as well as make connections between old and new material.

How Interleaving Works in an EFL Environment

Reading and writing are two skills where interleaving could play an active role in the learning process. Spack (1985) discussed the notion of writing before one reads as a method to express experiences, attitudes, or issues as they relate to the reading text. For example, if the book topic is a Disney story, students could write about their personal experiences of visiting Disneyland or watching Disney movies.

Keeping a journal is another method, helping students to digest and become aware of their reactions to what they have read. Students could copy passages from the book that have a special meaning to them on one half of the page and respond to them on the other (Zamel, 1992). These responses could be reflections, thoughts, ideas, or summaries of what students have read.

A final possibility would be to interleave reading and writing through free or voluntary reading which encourages students to read outside of class under less structured conditions (Hirvela, 2004). As students read various types of texts, they are encouraged to write about the grammatical or lexical features, organization of the story, and expressions which they may have trouble understanding. This type of reflective writing will enable students to improve their reading skills and build the groundwork for future writing.

Regular Testing

Regular testing enables students to recall more because the material is cycled back allowing the student to add layers of context and meaning each time (Rohrer & Taylor, 2007). Arnold and McDermott (2013) found that students who are regularly

quizzed have two advantages over those who are not: (1) they possess a more accurate idea of what they know and do not know, and (2) they possess a strengthening of learning that results with the continual retrieval of information. Wang and Aamodt's (2011) research showed that if students are tested on coursework a month apart, they are likely to recall it for a year or two. If they are tested on coursework a week apart, they are likely to recall it for 10 to 20 weeks. So, regularly testing students by including both old and new information in the tests helps to improve recall. Unfortunately, one must use tests that require students to supply the answer, that is, fill-in-the-blank, essay, or short answer. These types of tests appear more effective than simple recognition tests like multiple choice or true and false tests (Brown, Roediger, & McDaniel, 2014; Wang & Aamodt, 2011).

How Regular Testing Works in an EFL Environment

The most effective way to implement regular testing is to give students weekly quizzes which are corrected in class. This not only improves learning but students understand their mistakes immediately allowing the teacher to better understand what students are retaining, and what needs to be covered again. For example, in the university setting a semester runs for fifteen weeks resulting in a lot of quizzes. At the beginning of the semester, the teacher could inform students that they can pick ten of the quizzes that will become part of their final grade. This way, if a student does very poorly on a quiz, they have the option of dropping that quiz from the final assessment. The quizzes would contain material studied during the previous weeks, requiring students to recall the information. These quizzes should not be thought of as separate from the lesson, but as an integral part of the lesson itself. Regular testing enables students to continually assess their learning and retain information longer.

Conclusions

While students have depended on quick fix learning strategies for many years, research has proven that there are better, more effective strategies available which result in longer-term storage and stronger retrieval. When the brain is recalling information, it is doing something different, harder than simply reviewing information. By spacing out retrieval attempts, more effort is needed to recall the content. Interleaving various topics or skills creates connections between material that is already known and new material, enhancing the ability to recall the material later. Regular testing provides opportunities for students to review previous learning, check what they know and do not know, strengthening retrieval. The learning plateaus that students face when relying on popular mass-practice methods for studying do not have to be inevitable if teachers equip them with appropriate strategies for learning.

References

Ambrose, S., Bridges, M., DiPietro, M., Lovett, M., & Norman, M. (2010). *How learning works: Seven research-based principles for smart teaching*. San Francisco, CA: Jossey-Bass.

Arnold, K. M., & McDermott, K. B. (2013). Test-potentiated learning: Distinguishing between the direct and indirect effects of tests. *Journal of Experimental Psychology: Learning, Memory and Cognition, 39*(3), 940-945.

Brown, P., Roediger, H., & McDaniel, M. (2014). *Make it stick: The science of successful learning*. Cambridge, MA: Harvard University Press.

Bjork, R., & Bjork, E. (1992). A new theory of disuse and an old theory of stimulus fluctuation. In A. F. Healy, S. M. Kosslyn, & R. M. Shiffrin (Eds.), *From learning processes to cognitive processes: Essays in honor of William K. Estes* (vol. 2) (pp. 35-67). Hillsdale, NJ: Erlbaum.

Bjork, E., & Soderstrom, N. (2015). Learning versus performance. *Perspectives on Psychological Science, 10*(2), 176-199.

Chamot, A. U. (2005). Language learning strategy instruction: Current issues and research. *Annual Review of Applied Linguistics, 25*, 112-130.

Crow, J. T., & Quigley, J. R. (1985). A semantic field approach to passive vocabulary acquisition for reading comprehension. *TESOL Quarterly, 19*, 497-513.

Hall, K. G., Domingues, D. A., & Cavazos, R. (1994). Contextual interference effects with skilled baseball players. *Perceptual and Motor Skills, 78*, 835-841.

Hirvela, A. (2004). *Connecting reading and writing in second language writing instruction*. Ann Arbor: University of Michigan Press.

Landauer, T. K., & Bjork, R. A. (1978). Optimum rehearsal patterns and name learning. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory* (pp. 625-632). London, UK: Academic Press.

Roediger, H., & Karpicke, J. (2006a). The power of testing memory: Basic research and implications for educational practice. *Perspectives on Psychological Science, 1*, 181-210.

Roediger, H., & Karpicke, J. (2006b). Testing enhanced learning' taking memory tests improves long-term retention. *Psychological Science, 17*, 249-255.

Rohrer, D., & Taylor, K. (2007). The shuffling of mathematics problems improves learning. *Instructional Science, 35*, 481-498.

Spack, R. (1985). Literature, reading, writing, and ESL: Bridging the gaps. *TESOL Quarterly, 19*, 703-725.

Sousa, D. (2011). *Educational neuroscience*. Thousand Oaks, CA: Sage.

Taylor, K., & Rohrer, D. (2010). The effects of interleaved practice. *Applied Cognitive Psychology, 24*, 837-848.

Wang, S., & Aamodt, S. (2011). *Welcome to your child's brain. How the mind grows from conception to college*. New York, NY: Bloomsbury Publishing.

Willis, J. A. (2006). *Research-based strategies to ignite student learning*. Alexandria, VA: ASCD Publications.

Wittrock, M. C. (1974a). A generative model of mathematics education. *Journal for Research in Mathematics Education, 5*(4), 181-196.

Wittrock, M. C. (1974b). Learning as a generative process. *Education Psychology, 19*(2), 87-95.

Zamel, V. (1992). Writing one's way into reading. *TESOL Quarterly, 26*, 463-485.

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[JALT PRAXIS] MY SHARE

Philip Head and Gerry McLellan

We welcome submissions for the My Share column. Submissions should be up to 600 words describing a successful technique or lesson plan you have used that can be replicated by readers, and should conform to the My Share format (see the guidelines on our website below).

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Welcome to the latest edition of My Share. Once again, summer is upon us and, I, for one, am looking forward to the holidays, in hopes to escape the humidity of the city. I am counting the days until I can board my flight, and I am sure that many readers are also preparing for the last leg of the first semester. Exams will be foremost on the minds of many, and preparing, administering, and marking exams is the final hurdle before thoughts can turn to meeting up with family and friends and spending some time on R and R. Before all that, however, we have some great articles to help us get through those more difficult lessons.

Firstly, Gary Henscheid introduces us to an idea that helps students learn English by telling traditional Japanese stories. Next, Nick Caine utilizes the BBC Radio 4 program, Desert Island Discs*, to help motivate students to write and speak. Douglas Perkins and Adam Pearson then show us a way to introduce foreign geography and culture into the classroom. Lastly, Richard Buckley shows us his approach to help students learn vocabulary.*

In this month's online edition, Nick Caine shows us how to make a video wall using Padlet and Drew Larson has an idea for how to get students talking more in the classroom.

Draw and Tell

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Quick Guide

- **Keywords:** *Japanese stories, folk legends, memory, recall*
- **Learner English level:** *Junior high to high school*
- **Preparation time:** *15-30 minutes*