TRANSFER OF INFORMATION

How do Students Learn and Retain New Information?
A Practical Application of the Deans for Impact Report, *The Science of Learning*

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This article is a practical application of the 2nd Key Question in Deans for Impact Report, The Science of Learning. The second question of the Report is, "How do students learn and retain new information?" There are two cognitive principles which support this question. 1) Information is withdrawn from memory just as it went in. To support this principle several strategies and examples were provided, such as: Cooperative learning, Mnemonics, and Question Generation. 2) Practice is essential to learning new facts, but not all practices is equivalent. 3) strategies also support this principle: Deliberate Practice, Quizzing, and Feedback. The Deans for Impact Report is supported by the strategies and examples in this article.

Keywords: Cooperative Learning, Mnemonics, Question Generation, Quizzing, Feedback, Deliberate practice

The purpose of The Deans for Impact: The *Science of Learning* (2015) report (DFI) was to provide colleges of education and educational practitioners with an overview of how students learn and possible implications for the classroom. The second question of the DFI report, "How do students learn and retain information?" was examined under the framework of two cognitive principles. These cognitive principles hinge on the impact of memory recollection and the use of information through practice. The first cognitive principle focuses on a students' ability to retain information and how attaching meaning to that information makes it more likely to be recalled. The second cognitive principle argues that practice is vital for students to learn new information but not all practice has the same impact on student learning. Understanding these cognitive principles and the impact each has on student learning and retention of information can have a positive influence on how practitioners develop and reinforce a variety of new methodologies.

In order to achieve this objective, this article includes a short description of each cognitive principle as conveyed by the DFI (2015). Following these descriptions, this article will provide examples for educational practitioners that demonstrate how different teaching and learning strategies can be integrated into learning environments to improve learning. These recommendations can be implemented to enhance learning opportunities and promote success for students.

COGNITIVE PRINCIPLE 1

Information is often withdrawn from memory just as it went in. We usually want students to remember what information means and why it is important, so they should think about meaning when they encounter to-be-remembered material.

According to the research in the DFI report which substantiates some long held beliefs within theories of teaching and learning, students retain more information when they apply their own meaning to the material. The following strategies can be used by practitioners to have students apply meaning to information for better retention.

Strategy 1: Cooperative Learning.   Effective cooperative learning strategies such as small group problem solving, reflective discussions, or directed conversation with peers provide students with opportunities to develop a deeper understanding of content by requiring individuals to construct their own meaning. Having students explain information to each other has been shown to be an effective teaching and learning technique for students (Li & Lam, 2013). It requires students to build an understanding of and apply meaning to the material in order to explain it to others. Students who explain information are better at retaining material (Boud, Cohen, & Sampson, 2014). Students are then able to answer questions in multiple forms of assessment because they have made meaning of the material at a higher cognitive level. For some students, cooperative learning structures make it easier for them to learn concepts explained by and to their peers rather than merely hearing the information in a lecture format from their teacher. In order for students to capitalize on cooperative learning, the teacher must take on the role of a facilitator allowing students to construct their own meaning.

Examples:

- Math or Science problems have been assigned to students. The students work in small groups or partners to solve the problems. Once solved, students are encouraged to explain the concept, process, and solution to the class.
- Book Groups – Students work in small groups to read a text. Before, during and after the text has been read, the group discusses the text, based on teacher or student driven questions. Participation in this group encourages comprehension and requires recall of information from the text.
- Individuals are assigned a problem (math/science) or question related to a text (reading/social studies). After solving the problem or question independently, the student works with another student or in a small group where solutions are exchanged.

These types of strategies require that the teacher be willing to give up some control of the teaching and learning process and trust that the student groups, through engagement and discussion, will generate their own understandings, creating more meaningful experiences with the information and increasing the potential for memory storage.

Strategy 2: Mnemonics.   There are a variety of mnemonic strategies that educational practitioners can use to have students attach meaning to unfamiliar information. Mnemonic

devices can be connected to a visual, auditory, verbal or tactile stimulus that is related to the material. The concept behind each strategy is for students to take certain pieces of the information and connect them to unrelated interactive keys. These keys must be student created to allow for their personalized connection to meaning to improve retention. The mnemonic process provides learners with a systematic approach to recalling information. Also, students often retain the information in the same manner in which it was received. When mnemonic strategies are written or recited, they will most likely be recalled in the same manner.

Examples:

- Acronym Creation- Students use the first letter of each piece of information to create an acronym, name, or sentence to remember information, such as **Roy G. Biv**, which allows for students to remember the colors of light in order, **R**ed, **O**range, **Y**ellow, **G**reen, **B**lue, **I**ndigo, and **V**iolet.
- Keyword Method- "Carta" meaning "postal letter," the keyword could be related to the definition via a picture of a letter inside a shopping cart (Peters & Levin, 1986). By taking the image of the literal definition of the word and placing it inside an image that sounds like the vocabulary word, a student has created an interactive key to remember the desired information.
- Word Splash- Students create a word splash of vocabulary, names, and concepts from the to-be-remembered information. Then students apply meaning to the words through the use of the same fonts, colors, size, and direction. Such as: **Money-Treasury-Alexander Hamilton.** Students connected money (in the color green) to treasury via color and font because the Treasury Department deals with money. Then Alexander Hamilton is connected the same way because he was the first Secretary of Treasury.
- Songs and Rhymes – Students can use tunes of familiar or catchy songs to help remember concepts such as days of the week, body parts or months of year. For example, the days of the week can be sung to the tune of "Clementine." Multiplication raps help students memorize multiplication facts through raps.

Strategy 3: Question Generation.   Teaching students how to generate quality high level questions can positively impact comprehension and memory retention. Question generation however, is not an exact procedure but more a guideline for students to create their own processes to apply deep meaning to information. Questions that promote deep explanations typically begin with why, why-not, how, what-if, how does X compare to Y, and what is the evidence that supports X (Pashler, et al., 2007). As students both create and answer these deeper questions, their understanding of material is more likely to be retained as students must employ cognitive strategies to process the information.

Examples:

- After teaching students the question structure and levels they will encounter on end of course tests, students will create their own end of course questions and share-out (and

explain) their reasoning with classmates. Students will then answer these student generated questions and explain their thinking.

- Prior to beginning a unit, students generate their own questions after a quick survey of the key concepts, facts, and procedures. These questions are then readdressed as the students are taught the material.
- Teachers have students generate questions after they have been taught specific concepts. The teacher then reintroduces the questions at the beginning of later classes and requires the student who created the question to explain the answer.
- Formal instruction of questioning strategies and vocabulary is important in guiding students to create deeper thinking prompts. Teachers can model and then release students to use questioning techniques in all subjects.

COGNITIVE PRINCIPLE 2

Practice is essential to learning new facts, but not all practice is equivalent.

Practice is a regimen of effortful activities designed to optimize improvement (Ericsson, Krampe, & Tesch-Römer, 1993). It is a common understanding that for one to become proficient or exceptional at any task, academics, sports, music, etc., there must be time devoted to practice. The DFI (2015) report stresses the importance of practice, but cautions the practitioner to remember that not all practice has the same effect on learning. The following strategies and examples can be used by practitioners to increase the quality of practice for students which can positively affect student outcomes.

Strategy 1: Deliberate Practice. This type of practice is the intentional repetition of a skill, trait, or information until the individual or group has mastery. Individuals set aside specific times and develop plans to practice for the purpose of improving skill. The more time spent upon the mastery of one skill, the more likely an individual is to become proficient or exemplary at it. The level of performance can be increased even by highly experienced individuals as a result of deliberate efforts to improve (Ericsson, Krampe, & Tesch-Römer, 1993). It is important to remember that for any level of practice to be effective it should be accompanied by feedback. Practice does not make perfect, practice makes permanent. Only perfect practice makes perfect (Sousa 2005).

Examples:

- Repetition- students practice reciting or performing the desired information over and over with the teacher making adjustments throughout the process. In a chorus or music class, the students sing the desired piece repeatedly as the teacher makes adjustments to improve the performance of the group. Similarly in a math class, teachers give a set of problems depicting the same steps or skills after teaching a concept for students to practice.
- Interleaved practice- Once some level of mastery is achieved on a specific set of steps or skills for different tasks, problems from the course are rearranged so that a portion of each assignment includes different problems (Rohrer, Dedrick, & Stershic, 2015).

Therefore, students must practice a variety of concepts to complete the assignment. This provides intentional practice of different skills. Several problems of the same concept type can be "blocked" together so that the students are completing interleaved blocks.

- Games – Games such as flashcards, playing concentration, or speed rounds of reciting math facts are fun ways to incorporate deliberate practice of a variety of skills ranging from vocabulary to math.

Strategy 2: Quizzing.   The use of quizzes to check for understanding is a common practice among educators; however, using quizzes as a means to practice concepts is often overlooked. Quizzes provide educators with a glimpse into what their students' have retained and what topics may need to be revisited. At times, teachers may assign a grade to the quizzes to encourage students to study the to-be-remembered material. In addition, pop quizzes and informal assessments can be utilized as low or no stake methods to obtain similar information. Quizzes can be more than just a knowledge check; they can also be opportunities to provide constructive feedback, identify important material, and to re-expose students to important concepts. Educators may even view formative assessments, such as quiz performances, as an assessment of how they are doing in their teaching rather than how students are doing in their learning. Much of this may fly in the face of college instructional designs in which a student participates in one or two "midterm" exams and a concluding final exam at the end of a semester. This instructional design could only be expected to have a positive learning outcome for students with the strongest sense of self-regulation combined with an independent understanding of these cognitive principles.

Examples:

- Warm ups- A low stakes or no stakes quiz at the beginning of class in which the educator can check on the retention of knowledge of recently taught material usually from the day before. Warm ups allows the practitioner a quick and accurate picture of learners' knowledge or mastery. Warm ups also serve to remind learners which material is important by re-exposing them to the content after time.
- Unit Quizzes- Held at the end of an objective or unit, these quizzes focus on the content that has recently been taught. While these quizzes are graded, they should be used to identify which material needs to be retaught before the final assessment. By routinely conducting quizzes at the end each objective or unit, educators are also employing the testing effect. Simply put, if students know there is a quiz or test on the material they are being taught, they will focus on retaining the information.
- Exit Slips – Exit slips are informal assessments where students simply write down what they recall (or learned from class) and hand it to the teacher as they walk out of the classroom. Through this activity, students reflect upon their understanding of information from the day's lesson. This informs the teacher of which students are ready to move to the next topic and which students may need extra support.

Strategy 3: Feedback.   It is important to remember that for any level of practice or implementation of assessments to be effective it should be accompanied by feedback. This feedback should be authentic, meaningful, and1 designed to help students achieve mastery.

Feedback is an essential component of ensuring that practice and quizzing are beneficial and serve a true purpose. Feedback should not only focus on right or wrong answers and a letter "grade" but should also provide students with constructive guidance in relation to their performance. Teachers should be sure to use feedback strategies that are age appropriate and goal oriented. (Teaching Works, n.d.)

Examples:

- Conferencing – Teachers meet briefly with each student to assess progress in relation to their practice. When appropriate, individual conferencing after an assessment can provide students with specific goals and skills to improve. Conferencing also provides validity for student work.
- Checklists or Rubrics- These documents can provide specific information regarding student performance in relation to the teacher's expectations and help focus goals and expectations. They help the learners to begin with the end in mind. Providing models of exemplary finished work can be worth pages of instructions before work begins.

CONCLUSION

The DFI (2015) report asked, "How do students learn and retain information?" and provides two cognitive principles to answer the question. Cognitive Principle 1 focused on students applying meaning to the material that was to be remembered. Cognitive Principle 2 focused on the importance of quality practice. Educational practitioners, colleges of education, and teacher preparation programs can use these principles as guidelines for selecting teaching practices and reflecting on the effectiveness of traditional practices. The examples mentioned in this article are recommendations that support these principles for practitioners to implement in classrooms. Teachers can increase student achievement by focusing on the application of meaning to the material by the learners and ensuring students have consistent, accurate practice. In strengthening the learning and retention of knowledge and understanding for students, educational practitioners are supporting the students' learning and providing a greater chance for success in their academic endeavors.

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