SMART TEACHING STRONGER LEARNING

Practical Tips From 10 Cognitive Scientists

Edited by Pooja K. Agarwal, Ph.D.
Lead author of *Powerful Teaching*

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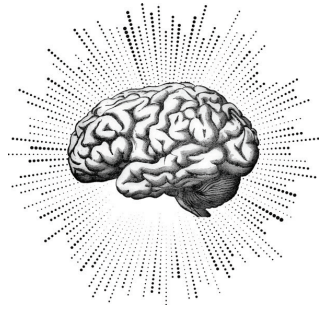

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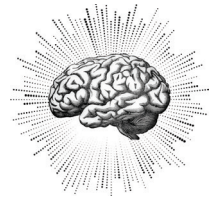

8

Transfer of Learning

Foster Students' Application of Knowledge

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Imagine that you are introducing the water cycle at the beginning of a science unit. Several days later, one of your students is walking outside. She observes a puddle that was visible in the morning, but it vanished by the afternoon. Will your student infer — drawing on knowledge from your lesson — that evaporation occurred?

Transfer of learning, or simply transfer, is the application of learned information in new situations. As educators, a fundamental goal of our instruction is that learning inside our classrooms will be applicable outside our classrooms, beyond a specific lesson, practice problem, or diploma.

How can you help students successfully apply what they have learned from one lesson to another, from one class to another, or from school to the real world? In this chapter, I share cognitive science research, practical teaching strategies, and potential challenges for

enhancing transfer. With these tips, you can effectively expand your students' learning from inside the classroom to new subject areas, ideas, and real-world applications outside the classroom.

Transfer is More than Ordinary Learning

Transfer is more than the remembering of an isolated topic or concept. It involves the application of learning from an initial lesson or class to a *new* lesson or class. Cognitive scientists define transfer as extending what was learned to answer new questions, solve new problems, and facilitate new learning. In everyday life, transfer can be as simple as using information in a different way than before.

When students successfully transfer knowledge to a new situation, you often "know it when you see it:"

- An elementary school student applies their knowledge of ancient Egypt to a new lesson on ancient China
- A middle school student learns the formula for the Pythagorean theorem from an algebra class and then applies their knowledge when solving novel word problems
- A high school student writes a fiction short story and then applies their structure during literary analysis of a new story
- A college student completes a major in accounting and then applies basic accounting principles in a new job
- A medical student applies what they learn in medical school to clinical practice with patients
- An adult learner uses a flashcard app with multiple-choice questions to study for an exam with short answer questions

In each of these scenarios, if the student applies their learning in a new situation, then successful transfer has occurred. On the other hand, if earlier learning is not applied in a novel situation, then no

transfer has occurred. A critical factor in these real-world examples — and in all situations involving transfer — is that learners don't simply recall information; they have to use existing knowledge in new and different ways. That's what makes transfer essential to learning.

Transfer Comes in Many Forms

Transfer is defined by two main characteristics:

- The *type* of knowledge or concept to be transferred
- A change in *context* from where learning originally took place

When the change in knowledge or context is minor, it's called *near transfer*, and when it is more substantial, it's called *far transfer*.[1] Of course, learning is complex and transfer can involve many different changes in knowledge and in context. Educators typically think of transfer of knowledge, but transfer across contexts is important, too. To give a few examples, context transfer can include a change in the physical location for learning, a change in the type of exam format, or a change in the use of the information at school or in everyday life.

	NEAR TRANSFER ←		→ FAR TRANSFER
Knowledge	Ancient Egypt in 1330 BC vs. 1325 BC	Ancient Egypt vs. Modern United States	Ancient Egypt vs. Romantic Literature
Physical	Same classroom	Different schools	School vs. everyday life
Time	In the same lesson	Weeks or months later	Years later
Task	Pythagorean calculation vs. calculation with new numbers	Pythagorean calculation vs. calculation with word problems	Pythagorean calculation vs. calculation with authentic problems
Functional	Solely academic	Academic vs. professional	Academic vs. personal
Format	Same format as before	Written vs. oral responses	Verbal vs. non-verbal

Let's go through a few examples. Do these situations involve a change in the type of knowledge, the context, or both? Are they considered to be near transfer or far transfer?

- Extending information learned about ancient Egypt to a new lesson on ancient China is a change in knowledge
- Using the Pythagorean theorem for solving novel word problems is a change in context
- Applying accounting principles in a new job is a change in context
- Switching from multiple-choice flashcards to a short answer exam is a change in context
- Applying the basic structure of short fiction when giving peer-feedback on a new nonfiction essay is a change in both knowledge and context

Of course, several changes in context can occur simultaneously. For instance, when a medical student applies what they learned in a course while treating a patient, this involves transfer across time, physical location, and function. It's important to keep in mind that whether successful transfer occurs depends on how well knowledge was learned in the first place and also the different contexts that were involved in initial learning. When taking the next step, it's important to think not just about the knowledge you want your students to transfer, but also about the different contexts that you want involved. By being mindful about shifts in context, your students' near and far transfer will be flexible, robust, and successful.

Foster Transfer with Retrieval Practice

Retrieval practice in its many forms (clickers, mini-quizzes, practice problems, and so on) is excellent for improving learning at basic and complex levels (see Chapters 1 and 2).[2] If successful transfer

is the goal, then retrieval practice is definitely worth adding to your teaching toolbox. To achieve transfer, it's important to engage students in retrieval that's more extensive than standard practice questions and exercises. Here are three strategies to foster transfer using retrieval practice:

Implement Broad Retrieval Exercises

Have students retrieve not just one or two details from a lesson, but as much as they can possibly remember. Ask your students to write down everything they have learned from a lesson or everything they know about a specific topic (for example, you could ask, "Retrieve everything you know about the first stage of mitosis"). Because asking students to retrieve broadly encourages them to think about multiple aspects of the material to be learned, transfer increases. Keep in mind that with broad questions, students may need a hint or suggestion to connect prior learning in a new context.

Encourage Elaboration

Ask students to construct meaningful explanations with elaboration (see Chapter 9). This method involves more than retrieving what they have learned; it encourages thinking about the *why* and *how* of material to be learned. As a simple example, a science teacher could ask students to explain how lightning works. When students create coherent, logical explanations of a concept or topic, it improves their overall understanding and transfer.[3]

Mix Question Complexity and Format

Use a variety of questions for retrieval practice (lower and higher order, factual and conceptual, multiple-choice and short answer, etc.) to engage students in thinking about subject matter in different ways.[4,5] For example, you can scaffold a variety of questions that ask students to retrieve basic concepts, apply that information, *and* make an inference.

Feedback is the Key to Transfer

To effectively foster transfer, retrieval practice should be combined with feedback. You probably already do this with feedback clarifying misunderstandings during class or facilitating class discussion. Feedback not only helps students strengthen the knowledge that they already have; it also helps them fill in gaps in their knowledge. With feedback, your students will be better able to integrate what they have retrieved with the rest of the materials to be learned. Here are two strategies for effective feedback:

Provide Explanatory Feedback

Feedback that includes a thorough explanation of the correct answer promotes transfer.[6] Explanatory feedback should directly connect the correct answer with related concepts. Students should learn whether they retrieved the answer correctly and *why* the answer was correct. If feedback contains information beyond what was learned initially, such as novel concepts or examples, then students can build additional connections in their understanding.

Give Students Time to Process Feedback

Students have to actively engage in processing feedback in order to reap its benefits. Ideally, feedback should be self-paced without time limits. This gives students the chance to fully process the information being presented without being prematurely interrupted. In addition to time, effective processing of feedback takes energy and attention. It is sometimes easy to lose focus when it comes to learning from feedback. To improve student engagement, consider alternating back and forth between periods of retrieval practice and feedback, with breaks in between. This helps keep students "on their toes" as they retrieve and strengthen their learning.

Transfer of Learning Isn't Easy

Transfer is a fundamental "holy grail" of education. Successful transfer means that a high degree of understanding and flexible learning has been achieved. At the same time, transfer can be difficult to generate. You've probably had the experience where students may not remember what they learned from chapter to chapter, class to class, and especially not year to year. Even more frustrating, your students may remember knowledge, but it remains "inert" — they struggle to identify when it's appropriate to apply what they know. In fact, in over a century of research, cognitive scientists have discovered that successful transfer is far more challenging than you might expect.

A Classic Case of Elusive Transfer

In a famous study from the 1980s, students read a story about a military general seeking to capture a fortress that was located at the center of a country.[7] The problem in the story was that a large group of soldiers could not travel on only one road. The solution was that the soldiers had to travel in small groups, each taking a different road to reach the fortress.

After students in the research study finished reading about the fortress problem, they were asked to solve a new problem involving a physician attempting to irradiate a tumor. The problem was that a dose of radiation strong enough to destroy the tumor would severely damage nearby tissues if it was delivered all at once.

The solution to the radiology problem seems obvious: apply what was learned in the fortress problem by using smaller multiple rays. However, 43% of students failed to transfer what they had learned; they were unable to apply the simple solution from the fortress problem to solve the radiation problem.

Why Transfer of Learning is Challenging

Successful transfer is difficult to foster due to three major obstacles:

- Learners may not recognize that the knowledge they've acquired should be applied to a novel situation. This is especially the case when the transfer situation is highly dissimilar to the context in which the original learning took place. Differences in location, specific details, and how information should be used may cause learners to think that they are facing an entirely unfamiliar situation.

- Learners may recognize that they need to apply their knowledge, but they have trouble remembering the knowledge to be transferred. If they can't remember it, then they can't transfer it.

- Learners may attempt to apply their knowledge, but they do so inaccurately. In this case, although the first two obstacles have been overcome, transfer still fails to occur because knowledge has been applied in the wrong way. For example, a medical student that is treating a patient with a headache may correctly recall the relevant neurological concepts, but they could still select the wrong neurological treatment to apply.[8]

A Simple Hint Makes a Big Difference

In the study involving the fortress and radiation problems, students needed to accomplish the following:

- Remember the solution to the fortress problem

- Recognize that the fortress solution can be applied to the radiation problem

- Correctly apply the fortress solution to the radiation problem

When students were given a helpful hint that one of the stories they had read could be helpful in solving the radiation problem, nearly all of the students generated the correct solution. In this case, students' difficulty in transferring their knowledge was resolved with

a simple reminder. In your classroom, offer hints or prompts to ensure students recognize opportunities to transfer their learning. You can also empower students to foster their own transfer of learning independently: acknowledge that transfer is hard, that they should take time to fully process feedback, and to recognize when prior knowledge can be applied in new contexts.

Further Reading

McDaniel, M. A., Thomas, R. C., Agarwal, P. K., McDermott, K. B., & Roediger, H. L. (2013). Quizzing in middle-school science: Successful transfer performance on classroom exams. *Applied Cognitive Psychology*, *27*, 360–372.

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About the Author

Dr. Steven Pan (he/him) is an Assistant Professor of Psychology at the National University of Singapore in Singapore. Dr. Pan teaches courses on cognitive psychology and research methods. His research centers on understanding and enhancing human learning and memory, with a specific aim of developing learning strategies that yield durable and adaptable knowledge. Dr. Pan's work particularly emphasizes evidence-based approaches such as pre-testing, retrieval practice, and interleaving. He earned his Ph.D. from the University of California, San Diego.

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Chapter 8: Transfer of Learning

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In *Smart Teaching Stronger Learning*, renowned cognitive scientists from around the world share innovative teaching strategies that significantly **transform student learning**. This approachable resource distills key principles from the science of learning, with concise chapters and real-world examples for busy educators and leaders in K–12, higher education, and beyond.

Enrich your pedagogy, professional growth, and knowledge of the newest findings in educational psychology with **down-to-earth tips** straight from the source: cognitive scientists who are also classroom teachers. Learn how you already use evidence-based methods — such as retrieval practice, interleaving, and metacognition — and gain creative strategies to strengthen students' motivation, long-term learning, and success.

Pooja K. Agarwal, Ph.D. (editor) is a cognitive scientist and lead author of the book *Powerful Teaching: Unleash the Science of Learning*. Her award-winning research on how students learn has been published in prominent academic journals; featured in *The New York Times* and *NPR*; and recognized by the U.S. Department of Education. Drawing on her combined 20 years of experience as a scientist, public school teacher, and college professor, Dr. Agarwal shares practical research-based resources for thousands of educators around the world at *RetrievalPractice.org*.

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