Retrieval Practice

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Transfer

# RETRIEVAL PRACTICE AND TRANSFER OF LEARNING:

## FOSTERING STUDENTS' APPLICATION OF KNOWLEDGE

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## How can we 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?

Consider a teacher who introduces the water cycle at the beginning of a science unit. Several days later, a student is walking outside. She observes that a puddle, which was visible in the morning, has vanished by the afternoon. Will the student infer – drawing on knowledge from the teacher's lesson – that evaporation has occurred?

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

What does successful transfer look like? Which strategies are the most effective for fostering students' transfer of learning? In this guide, we share cognitive science research, evidence-based strategies, potential classroom challenges, and implementation recommendations for enhancing transfer. By harnessing the science of learning, we can **use evidence-based strategies to foster students' transfer** and application of knowledge to new situations. Let's expand learning from inside the classroom to new subject areas, ideas, and real-world applications outside the classroom.

## TRANSFER IS MORE THAN ORDINARY LEARNING

Transfer involves the application of learning – from a question, lesson, or class to a *new* question, lesson, or class. Cognitive scientists define transfer as "extending what was learned to answer new questions, solve new problems, or facilitate new learning," while in everyday life, it can be as simple as **using information in a different way than before**.

When students successfully transfer knowledge to a new situation, we often "know it when we see it." For instance:

- An elementary school student who applies their knowledge of ancient Egypt to a new lesson on ancient China
- A middle school student who learns about the Pythagorean theorem from algebraic equations and then applies it when solving novel word problems
- A high school student who writes a fiction short story, applying the basic structure of fiction learned through literary analysis in class
- A college student who completes a major in accounting and then applies basic accounting principles in a new job
- A medical student who applies what they learn in medical courses to clinical practice with patients
- A lifelong learner who uses a flashcard app to practice recalling information in multiple-choice format prior to an exam involving short answer questions

In each of these examples, if a student applies their learning in a new situation, then we can conclude that **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 all of these real world examples, and 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 it essential. **Transfer is more than ordinary learning** or remembering of an isolated topic or concept.

## TRANSFER COMES IN MANY FORMS

Every type of transfer can be defined by two main characteristics. First, all transfer involves some knowledge that is supposed to be transferred. That knowledge can range from a single concept to an entire subject. Critically, all transfer also involves a **change in context** from where learning originally took place. That change in context can be relatively simple or more complex. When the change is minor, it's called "**near transfer**," and when it is more substantial, it's referred to as "**far transfer**." As shown below*, transfer can involve many different types of changes in knowledge and in context.

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

Using the table above, consider our examples of transfer on the previous page. Applying knowledge of ancient Egypt to ancient China? The context change in this case involves a change in knowledge. Using the Pythagorean theorem for novel word problems? A change in task type. Applying the basic structure of fiction to writing a short story? Also a change in task type. Applying accounting principles to a new job? A change in functional context. Switching from short answer flashcards to a multiple-choice exam? A change in format.

Of course, several changes in context can occur simultaneously. For instance, when a medical student has to apply learning from a course to treating a patient, that can involve transfer across time, physical location, and function.

When implementing learning strategies aimed at fostering transfer, it's important to think not just about the ***knowledge*** we want our students to transfer, but also about the ***different contexts*** that are involved. By being mindful about shifts in context, students' near and far transfer will be flexible, robust, and successful.

*Adapted from Barnett & Ceci (2002), *Psychological Bulletin* [1]

# TRANSFER IS ROBUST WITH RETRIEVAL PRACTICE

Retrieval practice in its many forms (clickers, mini-quizzes, practice problems, and so on) is excellent for improving learning. As discussed in our guide, **How to Use Retrieval Practice to Improve Learning**, retrieval practice involves getting information "out" of students' heads by bringing information to mind. This act of "retrieving" information powerfully strengthens learning.

Beyond ordinary learning, certain forms of retrieval practice are also quite effective at fostering transfer. These methods typically involve retrieving information in a more extensive and deeper manner than standard practice questions and exercises. This increased effort and broader engagement with material can boost learning, understanding, and transfer. Based on rigorous scientific research, here we share three retrieval practice strategies for fostering transfer that provide the most "bang for your buck" when it comes to classroom implementation.

## Implement broad retrieval exercises

Have students retrieve not just one or two details from a lesson, but as much as they can possibly remember (for example, "Write down everything that you have learned in this lesson") or everything they know about a specific topic (for example, "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, improved transfer performance can result.[2] This technique is even more powerful when feedback is provided, which we discuss on the next page.

## Encourage meaningful explanations

Ask students to **construct meaningful explanations** (for instance, "Explain how lightning works."). This method involves more than retrieving "what" they have learned; it encourages thinking about the "**why**" and "**how**" of material to be learned. Creating coherent, logical explanations of a concept or topic helps improve overall understanding, which can benefit transfer.[3]

## Mix question complexity and format

Use a **variety of questions** (lower and higher order, factual and conceptual, etc.) which involve retrieval of different parts of information to be learned. Using a variety of questions prompts students to think repeatedly about the subject matter in different ways. Such questions can even involve applying information or making inferences (for instance, a question which asks for recall of details about a concept can be paired with another question which involves applying that information).[4]

**OUR RECOMMENDATION:**
Retrieve as much information as possible, and in meaningful and varied ways. Effective strategies include using broad retrieval exercises, constructing explanations, and including a variety of questions.

## TRANSFER, RETRIEVAL PRACTICE, AND FEEDBACK: A POWERFUL COMBINATION

To effectively foster transfer, retrieval practice should always be combined with **feedback**. Combining retrieval practice with feedback not only helps students strengthen the knowledge that they already have; it also helps them fill in gaps in their knowledge. As a result, students will improve their understanding and be better able to transfer their knowledge. Here we share four feedback strategies that, when combined with retrieval practice, show the most promise at fostering transfer.

### Post-retrieval feedback

After retrieval practice, give students the opportunity to review target information (such as a textbook chapter, a lecture video, or other lesson materials). This **post-retrieval feedback** helps students check whether the information they recalled was correct, and focus on the areas they had difficulty recalling. They will also be better able to integrate what they have retrieved with the rest of the materials to be learned. Improved overall understanding – and better transfer of learning – can result.

### Explanatory, detailed, or self-paced feedback

Feedback which includes a thorough **explanation** of the correct answer can also be effective at fostering transfer.[5] Such feedback should be **detailed** in that it connects the correct answer with related concepts. Ideally, feedback should also be **self-paced** or without time limits. This gives students the chance to fully process the information being presented without being prematurely interrupted.

When students are given sufficient time to learn from explanatory or detailed feedback, they don't just learn whether they retrieved the answer correctly; they learn about the correct answer and **why** it is correct. Further, if the feedback contains additional information beyond the initial material to be learned (such as other concepts or examples), then students can also make additional connections with that information. As a result, they are better equipped to apply their knowledge in a transfer situation.

## Making the most of feedback

An important caveat is that students have to **actively engage in processing feedback** in order to reap its benefits. Students must make a serious effort to pay attention and learn when feedback is provided. It is, however, 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. This helps keep students "on their toes" as they retrieve and study relevant information. Alternatively, you can lead the class in presenting (and discussing) feedback, rather than leaving students to do it on their own.

**OUR RECOMMENDATION:**
Use retrieval practice in combination with feedback that involves more than just the correct answer. Effective strategies include post-retrieval, explanatory, and detailed feedback, ideally at a student's own pace.

## TRANSFER & RETRIEVAL PRACTICE: EFFECTIVE AND LESS EFFECTIVE APPROACHES

Transfer is a fundamental "holy grail" of education for two reasons. First, 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**, so we are always in search of methods to develop it. When is retrieval practice effective and ineffective when it comes to transfer? Here are major highlights of what we know so far, based on cognitive science research.[6]

- Retrieval practice of all types is excellent at improving transfer from one question format to another, such as from short answer to multiple-choice. This includes all major question formats.
- For situations involving application of knowledge or making inferences, retrieval practice can greatly improve transfer as well. This is especially the case if broad retrieval questions are used in conjunction with explanatory or detailed feedback, and when learners know what information to apply or use. As we discuss on the next page, students may need a hint or suggestion to use prior learning in a new context.[7]
- For transfer to related materials, such as when students perform retrieval practice on one part of a chapter and later are assessed on a different part, transfer is generally limited. The exception is if broad retrieval questions, retrieval of meaningful explanations, and/or explanatory or detailed feedback are used. Then, successful transfer can occur.
- For transfer from one specific part of a fact or question to another, such as when students are first asked, "On **what** day did the Allies invade Normandy?" and are later assessed on, "**Where** did the Allies invade on D-Day?", transfer is often limited. However, when higher order questions, plus explanatory or detailed feedback are used for each fact or concept, successful transfer is possible.

The evidence to date indicates that retrieval practice can foster transfer across a variety of contexts, and it is most effective at doing so when the retrieval practice *and* feedback strategies discussed in this guide are implemented. It's important to keep in mind that whether successful transfer occurs depends on how well knowledge was learned in the first place, as well as the different contexts that are involved. Accordingly, you may need to try different combinations of retrieval practice with feedback to achieve optimal results for various types of transfer.

**OUR RECOMMENDATION:**
Among all learning techniques examined by cognitive scientists to date, **retrieval practice produces transfer performance that is as good as, and often better than, any other method available today**. If successful transfer is the goal, then retrieval practice is definitely worth adding to your teaching toolbox.

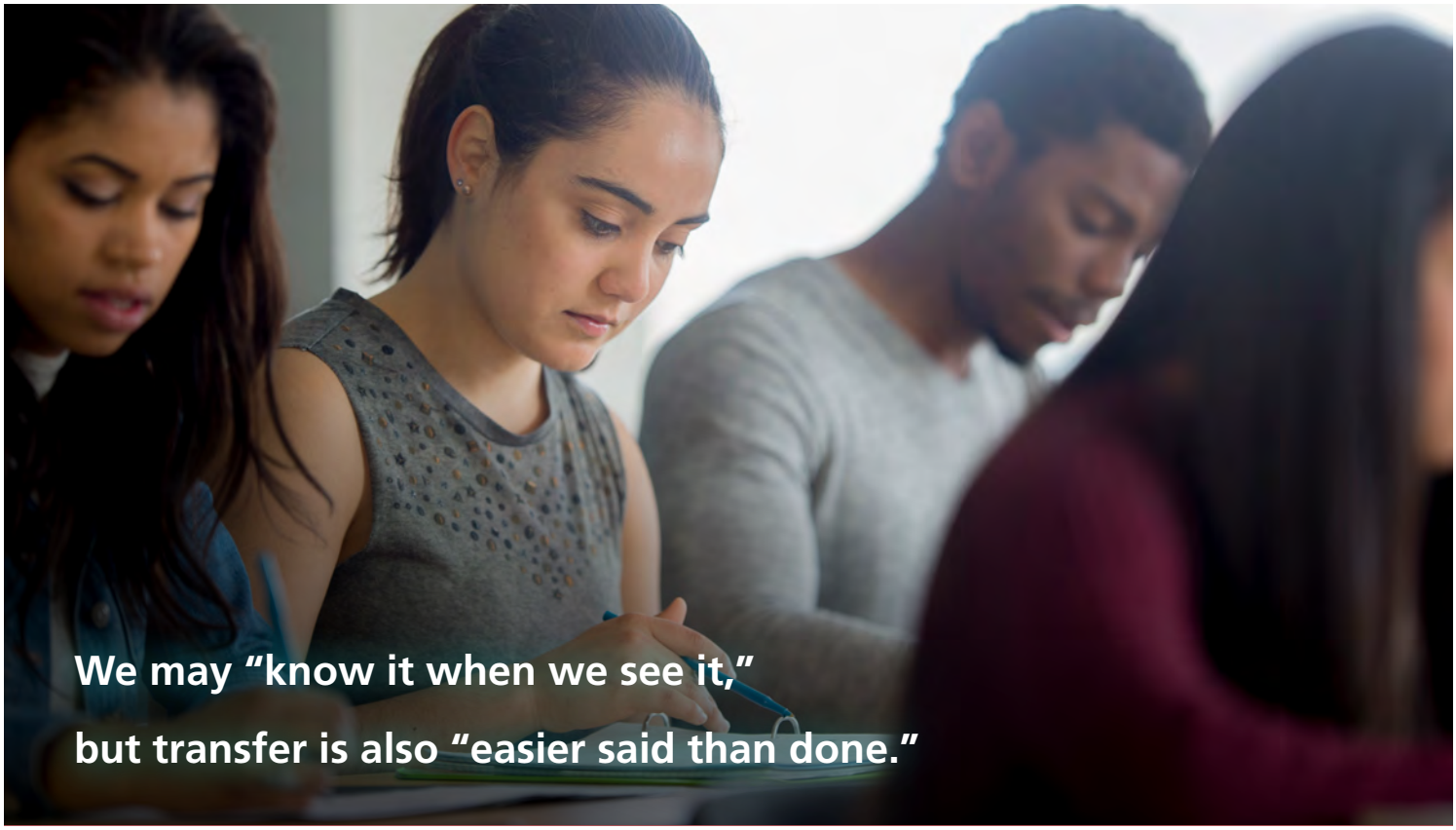
## TRANSFER OF LEARNING ISN'T ALWAYS EASY

While we often "know it when we see it," transfer of learning can be hard to identify. We've all 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, students may remember knowledge, but it remains "inert" – struggling 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 less common than we might expect.

### The "fortress" and "radiation" problems – a classic case of elusive transfer

In a famous study from the 1980s[8], students read several vignettes, one of which described a general seeking to capture a fortress that was located at the center of a country. The problem was that large groups of soldiers could not travel on any one of the many roads leading to the fortress. The solution was that the soldiers traveled in small groups, each taking a different road to reach the fortress. After students had finished reading this example 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, if delivered using a single ray, would severely damage nearby tissues. The solution – correctly making the analogy between the "fortress" and "radiation" problems – should be obvious. However, many students failed to transfer what they had learned to solve the new problem.

As illustrated by this example, successful transfer does not occur in numerous instances, including in some situations where we might usually expect it to. In other words, transfer is usually **"easier said than done."**



## Why is the transfer of learning not as easy as we expect?

Successful transfer is typically difficult to foster due to three major obstacles. First, learners may not **recognize** that the knowledge they've acquired should be applied in a novel situation. This is especially the case when the transfer situation is highly dissimilar to when the original learning took place. Differences in location, specific details, and how information is to be used (see the table on page 4 for examples) may cause learners to think that they are facing an entirely unfamiliar situation, similar to the research study described on the previous page. Second, learners may recognize that they need to apply their knowledge, but have trouble **remembering** the knowledge to be transferred. If they can't remember it, then no transfer occurs. Third, learners may not correctly **apply** knowledge to a transfer situation. In this case, although the first two obstacles have been overcome, transfer nonetheless fails to occur because knowledge has been used 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 select the wrong neurological information to apply.[9]

## Revisiting the "fortress" and "radiation" problems – how a simple change made a big difference

In the study involving the "fortress" and "radiation" problems, the critical difficulty students faced was to recognize that what they had learned should be applied in the new situation. However, when they were given a helpful hint (that one of the vignettes that they had read could be helpful in generating the answer), nearly all of the students generated the correct solution (that is, deliver the necessary dose of radiation through multiple rays, each of which is less powerful and thus not harmful). In this case, students' difficulty in transferring their knowledge was resolved with a simple reminder. Sometimes, it takes only a small change to successfully foster transfer.

## TRANSFER OF LEARNING: IMPLEMENTATION CHECKLIST

As educators, we want our students to transfer what they know to new topics, contexts, and situations. Based on extensive cognitive science research, retrieval practice combined with feedback is the most effective strategy for building successful transfer. Here are our evidence-based recommendations for fostering student transfer of knowledge within the classroom and beyond.

- ☐ Encourage students to use their knowledge in novel contexts and situations by acknowledging the challenge of transfer
- ☐ Foster both near and far transfer by varying learning contexts, including knowledge, task, and format
- ☐ Ask students to retrieve their knowledge broadly across topics, not specific key terms or sub-topics
- ☐ Expand meaningful explanations during retrieval by asking "why" and "how," not simply "what"
- ☐ Use a variety of question formats and complexities to foster flexible application of knowledge
- ☐ Combine retrieval with feedback to maximize the "bang for your buck" when fostering transfer
- ☐ Provide detailed feedback after retrieval, including explanations about correct answers
- ☐ Advise students to self-pace their review of feedback in order to fully process information
- ☐ Keep students actively engaged in their application and transfer of knowledge by alternating between retrieval practice and feedback
- ☐ Offer hints or prompts to ensure students recognize opportunities to transfer their learning

For research, resources, and tips, visit **retrievalpractice.org**

©2020 The development of this guide was supported by the National Science Foundation under grant DGE-1144086, awarded to the first author.
Any opinions, findings, conclusions, or recommendations expressed are those of the authors and do not reflect the views of the National Science Foundation.
We thank Tim Rickard for helpful comments on a draft of this guide.



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