Using Retrieval Practice and Metacognitive Skills to Improve Content Learning

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Teaser Text

How can teachers use retrieval practice to improve students' content learning from text? This article presents an exciting research-based method for enhancing content learning in classes like social studies and science.

Abstract

Classroom tests have been traditionally used to assess student growth and content mastery. However, a wealth of research in cognitive and educational psychology has demonstrated that retrieval practice (testing) as a form of low-stakes, rather than traditional high-stakes testing, can also be used as an effective pedagogical tool, improving long-term learning, reading comprehension, and metacognition. So, as teachers plan formative assessments to measure their students' learning, why not design those assessments as retrieval practice activities that simultaneously *improve* students' learning as well as assessing it? This article provides recommendations for how teachers can implement retrieval practice in the classroom to assess and optimize content learning.

Retrieval Practice, Close Reading, and Metacognitive Reflection to Improve Learning

Given the importance of engaging students in reading in content area classes to meet Common Core State Standards (CCSS), teachers could be using retrieval practice to enhance students' learning and memory. The following vignette describes a sequence of activities that a middle-school science teacher might implement that incorporates key components of retrieval practice—challenging questions, optimal timing, corrective feedback, and metacognitive reflection.

First, the teacher engages students in close reading of a text on biodiversity. She models by reading the first paragraph or section aloud with a focus on a specific comprehension strategy for informational texts (e.g., making inferences). She reads aloud, "Species are able to adapt and survive in a changing environment by creating a variety of life. This is called biodiversity, with *bio* meaning living and *diversity* meaning variation. An ecosystem is healthier when it has more than one type of organism to fulfill a specific role." Next, the teacher thinks aloud, saying "Why would biodiversity make an ecosystem healthier? I think…the variety would make the ecosystem more resilient." Then the teacher instructs the students to continue reading the next several paragraphs independently with the same focus on inferencing, pausing after each paragraph to think aloud with their partner. The lesson wraps up with a whole class discussion of the content to gauge their understanding (example adapted from Caccamise, Friend, Kintsch, Littrell-Baez, & Groneman, 2013). For example, the teacher might ask the student pairs to share with the class an example of an inference they made.

A few days later, as a retrieval practice activity, the teacher asks her students to recall information about what they learned during close reading. Without looking at the text, the students write short-answer responses for three to five questions covering key ideas from the text including both textbase questions derived directly from the text (e.g., "According to the text, what are key factors that contribute to biodiversity?") and situation model questions that incorporate the reader's background knowledge, inferences, and understanding of the textbase (e.g., "Write one to two sentences explaining how biodiversity affects the stability of an ecosystem."). After the students are done, the teacher assigns a quick metacognitive reflection activity saying, "Now, before checking our answers in the text, let's reflect on our answers. Please put a check mark next to the answer you are most confident about and a question mark

next to the answer you are least confident about." After the reflection activity, the teacher has the students reread the text, a form of close reading, and focus on evaluating their answers using the evidence in the text. This provides students with a purpose for returning to the text and provides feedback about the correctness of their retrieval practice responses. Then through whole class discussion, the students share their answers as the teacher creates a class answer key for the retrieval practice activity that can be displayed in the front of the room.

To conclude, students return to their metacognitive reflection. The teacher instructs the students saying, "Now check all of your short answers against the class key. Notice any differences between your responses and the class key. Was your most confident answer correct? Was your least confident answer incorrect? Were you surprised? Write one or two sentences about what you discovered about your understanding." For example, a student might write: "I thought that biodiversity was just about having lots of different types of organisms in an ecosystem. But now I know that the role that each organism plays is also important." This metacognitive reflection helps students to use the experience of testing their learning through retrieval practice and obtaining feedback through rereading to guide self-monitoring of their learning. Implementing retrieval practice in combination with close reading and metacognitive reflection in this way will serve to strengthen students' long-term retention of information learned from their text, while also helping them to improve their metacognitive skills. In this scenario, students have been given the opportunity to practice behaviors that expert readers engage in when they want to learn from text.

Retrieval Practice as a Learning Activity

Retrieval practice is the act of practicing retrieving information from memory in order to enhance its long-term retention. Through the inclusion of retrieval practice activities, educators

can both assess and reinforce students' learning. For example, recent studies show significantly higher performance (20-50%) on unit tests following retrieval practice (e.g., Butler, 2010; McDermott, Agarwal, D'Antonio, Roediger, & McDaniel, 2014). This increase in performance is known as the *Retrieval Practice Effect*, the *Testing Effect*, or simply *Test-Enhanced Learning* (Roediger & Karpicke, 2006). Although tests are traditionally used solely for assessment, the primary purpose of *low-stakes* retrieval practice is to help students integrate new information with what they already know and increase long-term retention and retrieval so that they may use this knowledge flexibly.

In the opening vignette, students participate in retrieval practice when they are quizzed a few days after the lesson. To illustrate another example, imagine that Jenny has just finished reading two chapters in her textbook, one about earthquakes and a second chapter about volcanoes. After Chapter 1, Jenny's teacher gives her a formative quiz on the causes and effects of earthquakes described in this chapter, followed by feedback about her performance. After Chapter 2, the teacher gives a summative assessment that covers the information in the first chapter and information in the second chapter on the causes and effects of volcanoes. On this summative assessment, will Jenny remember more material from Chapter 1 or Chapter 2? Retrieval practice research predicts that despite learning the content from Chapter 2 more recently, Jenny will be more likely to remember the information from Chapter 1 on the unit exam because she has practiced retrieving that information before. Thus, retrieval practice provides a method for giving low-stakes assessment of student learning that also improves retention of the material.

Why Should Teachers Be Interested in the Retrieval Practice Effect?

The benefits of retrieval practice are broad, including improvements in long-term retention, transfer of knowledge, reading comprehension, and metacognition (Butler, 2010; Carpenter, 2012). Thus, retrieval practice can provide a concrete method for engaging students in practice processing the content of text, more accurately monitoring their understanding, and critically evaluating the content. Research has also uncovered several factors that can boost the impact retrieval practice has on learning, including making questions more challenging (e.g., McDaniel, Thomas, Agarwal, McDermott, & Roediger, 2013), providing corrective feedback after retrieval practice (e.g., Butler, Karpicke, & Roediger, 2008), increasing the frequency of practice, and distributing practice opportunities throughout a unit (e.g., McDaniel, Agarwal, Huelser, McDermott, & Roediger, 2011).These findings are described in more detail in the sections below, with specific recommendations for classroom implementation.

For instance, when students engage in retrieval practice after reading an informational text, their performance improves significantly on both textbase questions (i.e., recalling information that is explicitly stated in the text) and inferential questions (i.e. information that can be inferred from the text but is not explicitly stated, as well as questions that go beyond the text) to answer a question about a new topic (Butler, 2010). These results show that offering retrieval practice opportunities in the classroom improves students' mental representations of text, strengthens their overall comprehension of the text, and allows them to think more flexibly to solve problems.

Thus, retrieval practice provides a research-based method for teachers to assess student progress while also enhancing student learning, retention, and transfer. This type of assessment, however, should be given as a low-stakes retrieval practice activity. By framing assessments in

this way, it gives students the opportunity to practice recalling and applying what they have learned without the pressure or high penalty often associated with high-stakes testing (e.g., McDaniel et al., 2011).

Using Retrieval Practice following Close Reading to Improve Learning from Texts

Close reading involves revisiting and rereading short passages of complex text with the intent to gain a deeper understanding of the author's writing (Frey & Fisher, 2013). During close reading, the goals of reading change each time students reread the text so that students must revisit the passage in order to synthesize answers to specific questions using support from the text (Frey & Fisher, 2013). Close reading may be used in content area classes, to contextualize students' learning of comprehension strategies (e.g., Caccamise, Friend, Littrell-Baez, & Kintsch, 2015; Perin, 2011). For example, Butler (2010) showed that following retrieval practice, undergraduate students were better able to recall information about structure and function from a science text and use that information to solve problems more effectively. The following scenario draws on this study to illustrate how a high school biology teacher could implement retrieval practice as part of a close read activity.

The teacher might ask students to: "Reread paragraphs 1 and 2 covering structure and function of wings. Circle signal words such as "similarly," "however", etc., that tell the reader something about how the information on bird wings and bat wings is organized and related across paragraphs. What does this tell us about the relationship between bird wings and bat wings in those paragraphs?"

According to Kintsch's *Construction-Integration (CI) Model* (1998), reading comprehension requires integrating information from the text (i.e., *textbase*) with the reader's prior knowledge on the topic to develop a *situation model* (also referred to as *mental model).*

The more effectively students are able to build the textbase and situation models, the more effectively they are able to apply this newly acquired knowledge in other learning contexts. While close reading involves carefully working with the text to answer text-related questions, retrieval practice requires that students work without the text to recall information learned from the text. In other words, close reading helps students build an accurate textbase while retrieval practice helps students build a rich situation model.

Continuing the previous example, on the day following the close read activity, the teacher could do a short retrieval practice activity, asking students: "Describe the characteristics of bird and bat wings you read about in class yesterday (i.e., a textbase question). Then answer the following application question in your notebooks: The U.S. Military is looking at bat wings for inspiration in developing a new type of aircraft. How might this new type of aircraft differ from traditional aircraft like fighter jets? (i.e., a situation model question)." In this example, retrieval practice strengthens students' memory for the retrieved information and provides an opportunity to go beyond the text, building a situation model of the topic. Close reading provides an effective way to help students build an accurate textbase. When working with individual informational texts, one way to introduce retrieval practice is to use it to follow a close reading session in order to help students build a rich situation model and enhance learning.

More recently, the CI framework has been extended from single document comprehension to comprehension of multiple documents. In this revised framework, students build a situations model that integrates both individual situation models for each text with source information and epistemic beliefs about each document. In other words, students build an *intertext model* (e.g., Bråten, Britt, Strømsø, & Rouet, 2011; Britt & Rouet, 2012). To illustrate, let's say that a middle school student in health class reads three texts on obesity from different

sources: a science article, a news report, and a blog. The student notes that the scientist agrees with the news reporter, but not with the blogger. The student then uses this *intertext* information to evaluate claims from each text source and synthesize their own argument. Retrieval practice activities can be added to help students build situation models of individual texts or intertext models that integrate multiple texts.

Using Retrieval Practice to Improve Metacomprehension and Self-regulation

Retrieval practice provides a way to improve students' metacognitive skills; namely, monitoring their own comprehension and regulating their study choices (Karpicke, 2009; Littrell, 2011). Metacognition, thinking about one's own thinking process, allows students to reflect on how well they have learned some information and predict how well they will retain that information so that they can study more effectively. Research suggests that students who are better at monitoring their understanding are also more effective at studying (e.g., self-regulating learning) and show higher exam performance in their classes (Dunning, 2011; Thiede, Anderson, & Therriault, 2003). Unfortunately, most students typically rely on surface characteristics of the text (e.g., length of the text, number of unfamiliar words) as cues to monitor their comprehension (Thiede, Griffin, Wiley, & Anderson, 2010). These are problematic because they are largely unrelated to the students' understanding of the content, and they can lead the student to assume that they understand the material because they can read it fluently. As a result, they actually overestimate how much they have learned. Students' overconfidence in their learning from reading may cause them to discontinue studying prematurely, resulting in poorer retention (e.g., Dunlosky & Rawson, 2012).

On the other hand, if students are prompted to answer retrieval practice questions that focus their attention on their textbase and situation model level understanding, they show

significant improvements in monitoring accuracy (Griffin, Wiley, & Thiede, 2008; Karpicke, 2009). These questions call attention to which information the student is able to recall, and the experience of retrieval practice provides student with feedback on their ability to explain what they have read from memory. For example, imagine a scenario where a social studies teacher assigns a retrieval practice activity to assess students' comprehension of several passages of a text on the three branches of the U.S. government. The retrieval practice activity is comprised of open-ended questions targeting both textbase and situation model understanding. Example questions are listed in Table 1.

Table 1. Sample Textbase and Situation Model Questions

Textbase Understanding:	*Situation Model Understanding:*
• Describe the three branches of the Federal Government. • Describe the function of each branch.	• What might happen if the Federal Government no longer had a system of checks and balances?

When students take retrieval practice tests, their monitoring is based on the experiences they had while engaging in retrieval practice, which feels more challenging and provides students with information to more accurately monitor their understanding at the situation model level (e.g., Karpicke, 2009). In this scenario, for instance, answering retrieval practice questions may alert the student that they did not understand a branch of the U.S. government, or perhaps what makes these concepts important. Thus, retrieval practice activities, particularly if they include situation model questions, provide critical information necessary for students to improve their metacomprehension and regulate their learning.

Although research supports broad applications of retrieval practice, we specifically address its use as a method for increasing students' learning from informational texts used in content areas such as social studies and science. With the implementation of the Common Core

State Standards for English Language Arts (ELA) and Literacy in History/Social Studies, Science, and Technical Subjects (CCSS), schools are placing greater emphasis not only on students' literacy skills, but also on students' abilities to build knowledge from reading texts and use that knowledge to solve problems (Caccamise et al., 2015; National Governor's Association [NGA] Center for Best Practices & Council of Chief State School Officers, 2010). In other words, students need to be able to retrieve information from memory in order to integrate it with new information and use what they know to solve problems. Retrieval practice supports CCSS by providing opportunities to practice and reinforce learning. For example, the CCSS include key points with goals for students' integration of knowledge and ideas (standards 7, 8, & 9). These points indicate that students should be able to identify and evaluate claims presented in text, determine whether or not the text supports the author's claims and compare and contrast information presented in multiple texts and other media sources, and use information from text and other media sources to synthesize new arguments (NGA, *CCSS*, pp.61-62). In order to successfully engage in this type of evaluation and integration, students must be able to understand and remember the content of different text sources, recall it from memory on demand, and actively construct meaning.

Recommendations for Designing and Implementing Retrieval Practice

The benefits of retrieval practice have been demonstrated in several classroom studies across a range of students and content areas, including middle-school social studies and science classes (cf. Agarwal, Bain, & Chamberlain, 2012; Roediger, Agarwal, McDaniel, & McDermott, 2011), high-school history classes (McDermott et al., 2014), and an online college-level science course (Brain and Behavior; McDaniel, Anderson, Derbish, & Morrisette, 2007). The following

sections highlight three recommendations to maximize the effectiveness of retrieval practice in content classrooms.

Use challenging question formats to maximize learning. The concept of *desirable difficulties* is an important part of the learning process, stating that while challenging tasks slow down initial learning, they lead to stronger long-term retention (Bjork, 1994). This is a concept that is present in recommendations for close reading activities which highlight the importance for selecting more challenging, high quality texts (Fang & Pace, 2013). Moreover, students demonstrate greater learning when retrieval practice questions are open-ended or short answer rather than multiple-choice (7-10% increase in performance, McDaniel, Anderson, et al. 2007; McDaniel, Roediger, & McDermott, 2007). This is because short answer questions require more effort on the part of the student to construct a response than if they received the same question in a multiple-choice format (Roediger & Karpicke, 2006). Similarly, students perform better on unit exams requiring the application of concepts if they are required to apply concepts during retrieval practice compared to simply memorizing and recalling facts (e.g., McDaniel et al., 2013). In other words, students are better able to use their knowledge flexibly to solve problems if retrieval practice includes challenging questions that require them to process the content deeply. Therefore, we recommend using short answer, essay, fill-in-the-blank or similarly challenging questioning formats. As a matter of practicality, peer evaluation of these low-stakes retrieval practice opportunities is one example of a viable alternative to teacher grading, given limits on teachers' resources for scoring open-ended retrieval practice output in a timely manner.

Offer frequent, distributed retrieval practice opportunities to improve learning. It is important to consider the timing of retrieval practice activities so that there is time between initial learning, retrieval activities, and the summative test. This helps to maximize the benefits

of retrieval practice (e.g., Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006; McDaniel et al., 2011). In addition, the effects of retrieval practice increase when material is queried more often before the summative test (e.g., McDaniel et al., 2011). For example, in an 8th grade science class, performance scores on chapter, semester, and end-of-the-year exams were best when the retrieval practice quizzes were given a few days after the initial lesson, with a 22-25% increase in performance compared to information that was not included in the retrieval practice quizzes. We recommend making some form of retrieval practice a part of the classroom routine (e.g., weekly). We also suggest making some of these activities cumulative in order to distribute practice of the content (Carpenter, Cepeda, Rohrer, Kang, & Pashler, 2012), so that students continue practicing retrieving material learned earlier, along with additional new material.

Provide corrective feedback to enhance learning and metacognition. The benefits of retrieval practice significantly increase when feedback is provided afterward (e.g., Agarwal et al., 2012; Carpenter, Pashler, & Cepeda, 2009). For example, Agarwal et al. (2012) report a 14% increase in later chapter exam scores when feedback was provided immediately following an earlier retrieval practice quiz. To be most effective, feedback should include correct answers for all of the practice questions (Pashler, Cepeda, Wixted, & Rohrer, 2005). Such feedback provides students the opportunity to correct their mistakes as well as strengthen memory for correct answers (Butler et al., 2008). For example, Butler et al. (2008) had 7th grade science students engage in retrieval practice with or without feedback and also rate their confidence in the accuracy of their responses. Retrieval practice with corrective feedback not only improved students' overall retention by 50%, but also reinforced the correct responses for which students' were not confident (Butler et al., 2008). In other words, including corrective feedback helps students adjust their incorrect answers and boosts long-term learning gains for initially correct

answers. We recommend that teachers provide feedback by discussing answers of retrieval practice quizzes in class, emphasizing the importance of both correcting mistakes and paying attention to correct answers. For instance, teachers can make metacognition an explicit part of the activity by asking their students to reflect on the experience of retrieval practice to monitor their own learning (e.g., "For which questions are you confident that you answered correctly? Which ones are you unsure about?"). After going over the answers, students can compare how well their monitoring matches their performance (e.g., "I wasn't sure about #5, but I really knew that one!" or "I thought I knew #3, but I was wrong.") and discuss why their answers were correct or incorrect.

Conclusions

Taken together, the research and recommendations presented here encourage conceptualizing formative assessments as opportunities for improving student learning, in addition to serving as a method for measuring growth. Current research provides a rich source of evidence supporting the use of retrieval practice to enhance students' long-term knowledge, depth of reading comprehension, accuracy of metacognitive monitoring, and self-regulation of learning. Teachers may use the recommendations presented here as a guide for designing retrieval practice activities so that students get the greatest learning benefits. To summarize, implementation of retrieval practice is most effective (1) when assessments employ challenging questions that require students to construct responses from memory and deeply process content; (2) when opportunities for retrieval practice are provided a few days after the initial lesson; and (3) when students are given corrective feedback so that they may update their metacognitive knowledge and better regulate their study to improve learning. Implementing retrieval practice

regularly in the content areas ensures that students process the textbase, build rich situation models, and improve content learning from informational text.

Take Action! Using Retrieval Practice to Improve Content Learning

1. **Frame formative assessments as retrieval *practice*.** Implement retrieval practice as opportunities for students to *practice* what they know using low-stakes testing. Performance should make up no more than 10% of the total class grade.
2. **Focus on textbase and situation model content.** Focus on key ideas in the text and target inferencing—across multiple sections and/or texts, and beyond the text(s). This will help students build a richer situation model of the content.
3. **Use open-ended questions for retrieval practice.** Challenge students by having them provide the answer rather than choosing among a selection of possible answers. For example, have students write short answers, essays, or fill-in-the-blank rather than using multiple-choice.
4. **Provide students with corrective feedback**. After retrieval practice, provide feedback to help students build their metacognitive skills. Corrective feedback can come in several forms including, but not limited to, focused close rereading, small group work to improve answers, or whole class discussion. Have students reflect on their understanding for *every* question to address their incorrect answers and to reinforce their correct answers.
5. **Give students frequent retrieval practice opportunities.** Weekly cumulative retrieval practice opportunities will re-expose students to current and previously learned material and strengthen long-term learning. These activities can replace high-pressure tests and quizzes.

6. **Encourage students to engage in metacognitive monitoring**. During reading, ask students to predict performance on upcoming retrieval practice activities. Following retrieval practice, have students compare their predictions to their actual performance so that they can reflect on their understanding of what they actually know and improve their future self-monitoring.

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