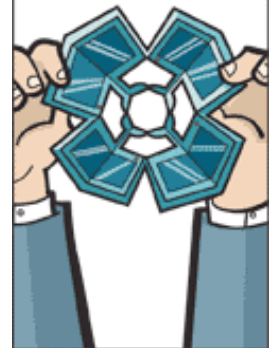




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You Will be Tested on This

Researchers are dusting off an old insight: To maximize classroom learning, quiz early and often

By DAVID GLENN

In the late 1930s, an ambitious graduate student named Herbert F. Spitzer asked thousands of Iowa sixth graders to read a short article about bamboo — an article he later described as "highly factual, authentic, of the proper difficulty, and similar in type to the material that children read in their regular school work."

He divided the students into 10 groups and gave them long multiple-choice quizzes ("What usually happens to a bamboo plant after the flowering period?") at varying intervals. One group, for example, was quizzed immediately after reading the article, then again the next day, and then a final time three weeks later. Another group was quizzed only once, three weeks after reading the article. The students did not know when they would be quizzed, and they did not keep the article, so they had no chance to study on their own.

The results were striking: On tests three or nine weeks later, students performed far better if they had previously been quizzed within 24 hours after first reading the article. When Mr. Spitzer

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wrote up his work in the *Journal of Educational Psychology* in 1939, he made a recommendation that might have made millions of students — and their teachers — groan: "Immediate recall in the form of a test is an effective method of aiding the retention of learning and should, therefore, be employed more frequently in the elementary school."

Suggestions like Mr. Spitzer's have been made for many decades, but they have never gained much traction. Now, however, a high-profile group of memory researchers at Washington University in St. Louis is working to rekindle interest in the "testing effect," as it is known. If teachers want to maximize their students' long-term learning, these scholars say, they should quiz them during every class session. And that emphatically includes college classes.

The purpose of this quizzing is not to motivate students to pay attention and to study more; if those things happen, the researchers say, they are nice side effects. The real point is that quizzing, if done correctly, is a uniquely powerful method for implanting facts in students' memory.

"In education today, people tend to think of tests as dipstick devices," says Henry L. (Roddy) Roediger III, a professor of psychology at Washington. "You stick it in to measure what people know. But every time you test someone, you *change* what they know."

With the help of a large federal grant, Mr. Roediger and his colleagues are scrutinizing the testing effect at a middle school in Illinois and in college classrooms at the University of New Mexico. They want to provide practical guidance for educators, and they also hope to shed light on several longstanding questions about how memory operates.

Making an Effort

The basic premise of the testing effect is easy to grasp. Just take the advice that your overbearing 10th-grade French teacher gave — "If you really want to learn the language, stop staring at your textbook and have a conversation in French" — and apply it to every domain of learning.

When a novice student strains to apply her fledgling knowledge of French in a conversation, she engages in what scholars of memory call "effortful retrieval," a process that sharply improves long-term retention of unfamiliar knowledge. But the power of effortful retrieval extends far beyond language learning: A student who has just read a complex article full of unfamiliar facts about 17th-century Poland will retain that information much better if he is quizzed — thus forcing him to retrieve the data from memory — than if he simply rereads the article two or three

times.

"The testing effect cuts against the lay understanding of memory," says Jeffrey D. Karpicke, who recently completed a doctorate at Washington University and will become an assistant professor of psychology at Purdue University this fall. "People usually imagine memory as a storage space, as a space where we put things, as if they were books in a library. But the act of retrieval is not neutral. It affects the system."

In a long series of recent studies, Mr. Roediger and his colleagues have examined the testing effect from several different angles: Is it better to use short-answer quizzes or multiple choice? Is it crucial to give students immediate feedback on their quiz performance? Does quizzing improve students' long-term learning of related material?

Andrew C. Butler, a graduate student at Washington, recently designed an experiment in which students watched videotaped lectures on consecutive days about three Impressionist artists: Berthe Morisot, Pierre-Auguste Renoir, and Edgar Degas. (None of the participating students had taken art-history classes, so this was unfamiliar territory.) Immediately after each lecture, a computer screen would train the students in one of three ways: by displaying facts from the lecture, which the students would simply read; by giving the students a multiple-choice quiz; or by giving them a short-answer quiz.

The students were randomly assigned into various sequences, and they all experienced each study method exactly once. For example, a student might see the Renoir lecture on Day 1 and take a short-answer quiz, see the Morisot lecture on Day 2 and simply read the facts, and see the Degas lecture on Day 3 and take a multiple-choice quiz. Another student might see the Morisot lecture on Day 1 and take a quiz, and so on; there were 27 different pathways in all.

A month later, the students were brought back to take a 90-item short-answer test that covered all three artists. This final test included some facts that the students had not reviewed at all. On those items, the students answered only 20 percent correct, on average. On the items that had been studied through rereading or through multiple-choice quizzes, the students averaged 36 percent correct. And on the items that had been studied through short-answer quizzes, the students averaged 47 percent correct.

For Mr. Butler, the implications are clear: Instructors should take a few minutes to give quizzes, preferably in short-answer format, at the beginning or end of each class session. "A lot of educators don't make the connection between their teaching tasks and their evaluation tasks," he says.

When given regular quizzes, Mr. Butler says, students are forced to retrieve facts from memory repeatedly, and they develop much deeper fluency in the material. Instructors might consider it a nuisance to construct and grade the quizzes, he says, but it's far worse to allow students to go 12 weeks between hearing a lecture and coughing up facts on a final exam. Students who wait to cram for a final exam rarely retain the material over the long term, even if they perform reasonably well on the final, Mr. Butler says.

"The way that we typically do things in education," Mr. Butler says, "seems almost reverse-engineered to produce the least possible learning."

Testing Effects

Tightly constructed experiments like Mr. Butler's are one thing. But Mr. Roediger and his colleagues are also looking at the testing effect in real-world classrooms.

A \$3-million, five-year grant from the Institute of Education Sciences, an arm of the U.S. Education Department, supports the team's research on social-studies and English classes at a middle school in Columbia, Ill., not far from St. Louis, and in Psychology 101 classes at the University of New Mexico at Albuquerque.

At the middle school, the Washington University researchers have worked with teachers to identify roughly 30 key facts in each of the students' textbook chapters. For half of those facts, the students are given daily quizzes, which the students answer using handheld "clicker" devices manufactured by eInstruction Corporation. The devices allow the students to receive instant feedback on their answers. On the final tests at the end of each unit, the students demonstrate significantly better recall of the quizzed facts than the unquizzed facts.

"We've produced a nice testing effect at Columbia Middle School," says Kathleen B. McDermott, an associate professor of psychology at Washington University. "You can see it very clearly in the data. What we want to do next year is to go back and say, Well, of all of the things that we did, what's crucial? What if they don't get that immediate feedback?" she asks. "What if we don't give them a prequiz at the beginning of the unit, to show them what they don't know?" Tweaking the procedure, Ms. McDermott says, should help to illuminate how the testing effect operates.

At New Mexico, Gordon K. Hodge, an associate professor of psychology, is experimenting with the testing effect in his large introductory courses. Every other week, he requires his students to take daily online quizzes on their own time, as homework. The federally financed study will compare his students' end-of-

semester retention of facts from the quizzes with their retention of facts they learned during the nonquiz weeks.

"Several years ago, our dean identified Psychology 101 as a 'killer course,'" Mr. Hodge says. "Some administrators were very concerned about how many students were failing. But we in the department didn't want to mend the problem by just making things easier. So we started to look for ways to help students improve their learning."

Contrary to the general wisdom of testing-effect research, Mr. Hodge's online quizzes are in multiple-choice rather than short-answer format. Creating and scoring short-answer quizzes for such large classes would be too difficult and time-consuming for the instructor, says Mark A. McDaniel, a professor of psychology at Washington who is working closely with Mr. Hodge on the project. "Maybe we're not that far away from the day when computers can score short-answer tests," Mr. McDaniel says, "but we're not there yet."

At Washington University, Ms. McDermott gives four-question short-answer quizzes at the end of every meeting of her 300-level course on human learning and memory. These classes tend to be small — around 20 students — so it is easy to give quizzes at every meeting, she says.

"Sometimes colleagues here will ask me about the quizzes," Ms. McDermott says, "and I'll explain to them why I do this. The hard part is standing firm when you announce it at the beginning of the course, and dealing with the resistance. But students are always going to complain about something in your course. It might as well be quizzes."

By the end of the semester, Ms. McDermott says, most students have come to appreciate the role the quizzes play in helping them absorb the course material.

Too Narrow?

Ms. McDermott says she tries to persuade her colleagues that writing and grading daily quizzes is really not so bad. But her colleagues sometimes come back with another objection: Don't these quizzes encourage students to concentrate on narrow, isolated facts, as opposed to the broader concepts and themes at the heart of the course?

Researchers still have a good deal to learn about that question, Ms. McDermott says, but they are starting to believe that frequent quizzing actually helps students absorb a broad range of material not directly included in the quizzes. Jason C.K. Chan, a newly minted Ph.D. at Washington who will become an assistant professor of psychology at Iowa State University this fall,

recently designed experiments that seem to demonstrate this. "In the process of retrieving Fact A," Ms. McDermott says, "if it takes you a minute to get there, you think, Hmm — what did I learn about this general topic? So in a sense, you're also retrieving Fact B and Fact C, even though that's not what you were directly asked to do."

Mr. Roediger, meanwhile, hopes that teachers and college instructors will take Mr. Spitzer's 68-year-old advice seriously, but he knows that it will be an uphill battle. "What I hear from teachers is, Quizzes would take time away from good learning activities," Mr. Roediger says. "But my point is, this is the best thing that you could be doing if you want them to learn. Give them a quiz, and give them feedback on that quiz."

LEARNING FOR THE LONG TERM

Psychologists at Washington University in St. Louis recently asked students to read a pair of articles.

- The **SSSS** group of students studied the articles during four consecutive five-minute periods.
- The **SSST** students studied the articles for three five-minute periods, and then tested themselves for five minutes by trying to write as many facts as they could remember on a blank sheet of paper.
- The **STTT** group studied the articles just once, and then tested themselves during three consecutive five-minute periods.

S = 5 minutes of study
T = 5 minutes of testing

Half the students were given a "final exam" five minutes after the end of this process. Here the SSSS students performed best. The other half of the students took their "final" a week later. Here the SSSS students performed by far the worst. It was a stark example of how testing helps to implant facts in long-term memory.

Final exam scores (Proportion of facts recalled)

Scores earned 5 minutes after the study/test session	83%
	78%
	71%
Scores earned 1 week after the study/test session	40%
	56%
	61%

SOURCE: Henry L. Roediger III and Jeffrey D. Karpicke, "Test-Enhanced Learning: Taking Memory Tests Improves Long-Term Retention," *Psychological Science* (2006)

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