How to help people learn

Julie Schell

The University of Texas at Austin
Harvard University
When thinking about your students’ learning, what keeps you up at night?
Do they remember? Does it help on a very practical level?

---- UG Professor
Many students learn very instrumentally, using summaries and not going to classes. How can we deepen this learning, within the possibilities of a class of 600 students?

——— UG Professor
Will they retain what they learn?

——— Harvard Professor
How boring I am and how little will be retained by the student.

——— Yale Professor
Disintteresse!!

——— Brazilian Professor
Their stress which inhibits their learning, and my pleasure in teaching.

— UG Professor
I worry about the fact that young people these days are stressed.

——— UG Professor
How do students spend most of their time learning?

A. Listening to lecture
B. Reading and re-reading materials
C. Taking notes and reviewing them
D. Quizzing themselves
“[Research] has demonstrated that college students tend to employ study strategies that are far from optimal.”
<table>
<thead>
<tr>
<th>Strategy</th>
<th>Percent who list strategy</th>
<th>Percent who rank as #1 strategy</th>
<th>Mean rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rereading notes or textbook</td>
<td>83.6 (148)</td>
<td>54.8 (97)</td>
<td>1.5</td>
</tr>
<tr>
<td>2. Do practice problems</td>
<td>42.9 (76)</td>
<td>12.4 (22)</td>
<td>2.1</td>
</tr>
<tr>
<td>3. Flashcards</td>
<td>40.1 (71)</td>
<td>6.2 (11)</td>
<td>2.6</td>
</tr>
<tr>
<td>4. Rewrite notes</td>
<td>29.9 (53)</td>
<td>12.4 (22)</td>
<td>1.8</td>
</tr>
<tr>
<td>5. Study with a group of students</td>
<td>26.5 (47)</td>
<td>0.5 (1)</td>
<td>2.9</td>
</tr>
<tr>
<td>6. “Memorise”</td>
<td>18.6 (33)</td>
<td>5.6 (10)</td>
<td>2.0</td>
</tr>
<tr>
<td>7. Mnemonics (acronyms, rhymes, etc)</td>
<td>13.5 (24)</td>
<td>2.8 (5)</td>
<td>2.4</td>
</tr>
<tr>
<td>8. Make outlines or review sheets</td>
<td>12.9 (23)</td>
<td>3.9 (7)</td>
<td>2.1</td>
</tr>
<tr>
<td>9. Practise recall (self-testing)</td>
<td>10.7 (19)</td>
<td>1.1 (2)</td>
<td>2.5</td>
</tr>
<tr>
<td>10. Highlight (in notes or book)</td>
<td>6.2 (11)</td>
<td>1.6 (3)</td>
<td>2.3</td>
</tr>
<tr>
<td>11. Think of real life examples</td>
<td>4.5 (8)</td>
<td>0.5 (1)</td>
<td>2.8</td>
</tr>
</tbody>
</table>
What is rehearsal-based learning?

Repetitive review of knowledge

Leads to weak, surface learning
People firmly believe they learn best by repeatedly putting knowledge into their brains.
People firmly believe they learn best by repeatedly putting knowledge into their brains.
“...because students often receive little or no direct instruction about how to learn they instead develop their own idiosyncratic strategies, which are likely to vary in effectiveness.”
“Restudying materials has limited effects on long-term retention and the ability to successfully use that material in the future.”
People actually learn best by taking knowledge out of or “retrieving it” from their brains.
The Power of Testing Memory
Basic Research and Implications for Educational Practice

Henry L. Roediger, III, and Jeffrey D. Karpicke
Washington University in St. Louis

ABSTRACT—A powerful way of improving one’s memory for material is to be tested on that material. Tests enhance future retention more than additional study of the material, even when tests are given without feedback. This surprising phenomenon is called the testing effect, and although it has been studied by cognitive psychologists sporadically over the years, there is a renewed effort to learn why testing is effective and to apply testing in educational settings. In this article, we selectively review laboratory studies that reveal the power of testing in improving retention and then turn to studies that demonstrate the basic effects in educational settings. We also consider the related concepts of dynamic testing and formative assessment as other means of using tests to improve learning. Finally, we consider some negative consequences of testing that may occur in certain circumstances, though these negative effects are often small and do not cancel out the large positive effects of testing. Frequent testing in the classroom may boost educational achievement at all levels of education.

and classes with only a midterm exam and a final exam are common. Students do not like to take tests, and teachers and professors do not like to grade them, so the current situation seems pragmically to both parties.

The traditional perspective of education is to view tests and examinations as assessment devices to measure what a student knows. Although this is certainly one function of testing, we argue in this article that testing not only measures knowledge, but also changes it, often greatly improving retention of the tested knowledge. Taking a test on material can have a greater positive effect on long-term retention of that material than spending an equivalent amount of time re-reading the material, even when performance on the test is far from perfect and no feedback is given on missed items. This phenomenon of improved performance from taking a test is known as the testing effect, and though it has been the subject of many studies by experimental psychologists, it is not widely known or appreciated in education. We believe that the neglect of testing in educational circles is unfortunate, because testing memory is a powerful technique for enhancing learning in many circumstances.
The Power of Testing Memory
Basic Research and Implications for Educational Practice

Henry L. Roediger, III, and Jeffrey D. Karpicke
Washington University in St. Louis

ABSTRACT—A powerful way of improving one's memory for material is to be tested on that material. Tests enhance long-term retention more than additional study of the material, even when tests are given without feedback. This surprising phenomenon is called the testing effect, and although it has been studied by cognitive psychologists sporadically over the years, only in recent years has there been a renewed effort to learn why testing is effective and to apply testing in educational settings. In this article, we selectively review laboratory studies that reveal the power of testing in improving retention and then turn to studies that demonstrate the basic effects in educational settings. We also consider the related concepts of dynamic testing and formative assessment as other means of using tests to improve learning. Finally, we consider some negative consequences of testing that may occur in certain circumstances, though these negative effects are often small and do not cancel out the large positive effects of testing. Frequent testing in the classroom may boost educational achievement at all levels of education.

and classes with only a midterm exam and a final exam are common. Students do not like to take tests, and teachers and professors do not like to grade them, so the current situation seems predestined to both parties.

The traditional perspective of education is to view tests and examinations as assessment devices to measure what a student knows. Although this is certainly one function of testing, we argue in this article that testing not only measures knowledge, but also changes it, often greatly. Improving retention of the tested knowledge. Taking a test on material can have a greater positive effect than simply restudying that material than spending an equivalent amount of time restudying the material, even when performance on the test is far from perfect and no feedback is given on missed information. This phenomenon of improved performance from taking a test is known as the testing effect, and though it has been the subject of many studies by experimental psychologists, it is not widely known or appreciated in education. We believe that the neglect of testing in educational circles is unfortunate, because testing memory is a powerful technique for enhancing learning in many circumstances.

Roediger & Karpicke, 2006
The Power of Testing Memory
Basic Research and Implications for Educational Practice

Henry L. Roediger, III, and Jeffrey D. Karpicke
Washington University in St. Louis

ABSTRACT—A powerful way of improving one’s memory for material is to be tested on that material. Tests enhance later retention more than additional study of the material, even when tests are given without feedback. This surprising phenomenon is called the testing effect, and although it has been studied by cognitive psychologists sporadically over the years, there is a renewed effort to learn why testing is effective and to apply testing in educational settings. In this article, we selectively review laboratory studies that reveal the power of testing in improving retention and then turn to studies that demonstrate the basic effects in educational settings. We also consider the related concepts of dynamic testing and formative assessment as either means of using tests to improve learning. Finally, we consider some negative consequences of testing that may occur in certain circumstances, though these negative effects are often small and do not cancel out the large positive effects of testing. Frequent testing in the classroom may boost educational achievement at all levels of education.

and classes with only a midterm exam and a final exam are common. Students do not like to take tests, and teachers and professors do not like to grade them, so the current situation seems preposterous to both parties.

The traditional perspective of education is to view tests and examinations as assessment devices to measure what a student knows. Although this is certainly one function of testing, we argue in this article that testing not only measures knowledge, but also changes it, often greatly improving retention of the tested knowledge. Taking a test on material can have a greater positive effect than just reading the material itself or spending an equivalent amount of time self-testing the material; even when performance on the test is far from perfect and no feedback is given on missed items. This phenomenon of improved performance from taking a test is known as the testing effect, and although it has been the subject of many studies by experimental psychologists, it is not widely known or appreciated in education. We believe that the neglect of using testing in educational curricula is unfortunate, because testing memory is a powerful technique for enhancing learning in many circumstances.

Roediger & Karpicke, 2006
The Power of Testing Memory
Basic Research and Implications for Educational Practice
Henry L. Roediger, III, and Jeffrey D. Karpicke
Washington University in St. Louis

ABSTRACT—A powerful way of improving one’s memory for material is to be tested on that material. Tests enhance learning retention more than additional study of the material, even when tests are given without feedback. This surprising phenomenon is called the testing effect, and although it has been studied by cognitive psychologists sporadically over the years, there is a renewed effort to learn why testing is effective and to apply testing in educational settings. In this article, we selectively review laboratory studies that reveal the power of testing in improving retention and then turn to studies that demonstrate the basic effects in educational settings. We also consider the related concepts of dynamic testing and formative assessment as other means of using tests to improve learning. Finally, we consider some negative consequences of testing that may occur in certain circumstances, though these negative effects are often small and do not cancel out the large positive effects of testing. Frequent testing in the classroom may boost educational achievement at all levels of education.

and classes with only a midterm exam and a final exam are common. Students do not like to take tests, and teachers and professors do not like to grade them, so the current situation seems paradoxical to both parties.

The traditional perspective of education is to view tests and examinations as assessment devices to measure what a student knows. Although this is certainly one function of testing, we argue in this article that testing not only measures knowledge, but also changes it, often greatly improving retention of the tested knowledge. Taking a test on material can have a greater positive effect on learning retention of that material than spending an equivalent amount of time studying the material, even when performance on the test is far from perfect and no feedback is given on missed information. This phenomenon of improved performance from taking a test is known as the testing effect, and though it has been the subject of many studies by experimental psychologists, it is not widely known or appreciated in education. We believe that the neglect of testing in educational circles is unfortunate, because testing memory is a powerful technique for enhancing learning in many circumstances.

Roediger & Karpicke, 2006
Repeated retrieval improves retention of knowledge and the ability to transfer that knowledge to new contexts.
What is retrieval?
Pulling information from memory
What is retrieval-based learning?
Learning resulting from pulling information from memory

Leads to strong, deep learning
Insights From the Science of Learning Can Inform Evidence-Based Implementation of Peer Instruction

Julie A. Schaal and Andrew C. Butler

Peer Instruction is a popular pedagogical method developed by Eric Mazur in the 1980s. Educational researchers, administrators, and teachers find Peer Instruction as an easy-to-use method that enhances active learning in their classroom. This paper presents insights from the science of learning that can inform evidence-based implementation of Peer Instruction.

Metacognitive strategies in student learning: Do students practise retrieval when they study on their own?

Jeffrey D. Karpicke

Purdue University, West Lafayette, IN, USA

Andrew C. Butler and Henry L. Roediger III

Washington University in St. Louis, MO, USA

Basic research on human learning and memory has shown that practicing retrieval of information (by testing the information) has powerful effects on learning and long-term retention. Repeated testing enhances learning more than repeated reading, which often explains limited benefit beyond that gained from the initial reading of the material. Laboratory research suggests that students who use retrieval strategies during study are more likely to learn the material than students who do not. The key is to ensure that students are retrieving information from memory in a way that enhances learning. This paper presents strategies that use self-studying (as opposed to active free-response questions) and to identify whether they would perform better on a final exam than students who did not.

Retrieval Practice Produces More Learning Than Elaborative Studying with Concept Mapping

Jeffrey D. Karpicke and Jared K. Newton

Education is often defined as learning activities that encourage elaborative studying, whereas activities that require students to practice retrieval, such as mapping and concept-mapping, are less common. Here, we show that practicing retrieval produces greater gains in memory than studying with concept mapping. The advantage of retrieval practice generalizes across tests identical to those used both in school science and in the psychology lab. The advantage of retrieval practice was demonstrated with tests that required comprehension and recall. Moreover, retrieval practice led to greater gains in memory than other strategies, such as concept mapping.

Retrieval-Based Learning: A Decade of Progress and Challenges

Jeffrey D. Karpicke

Purdue University, West Lafayette, IN, USA

© 2017 Elsevier Ltd. All rights reserved.

Introduction

A Primer on Retrieval-Based Learning

Direct Versus Mediated Effects of Retrieval

Balancing Retrieval Success and Retrieval Effort

Theories of Retrieval-Based Learning

Transfer-Appropriate Processing Strength and Retrieval Effort

Elaborative Retrieval Account

Epicodic Context Account

Manipulations of Initial Retrieval Practice on Retrieval Practice Compared to Restudy and Comparisons of Recall, Recognition, and Learning

Repeated Testing Produces Superior Transfer of Learning Relative to Repeated Studying

Andrew C. Butler

Washington University in St. Louis, MO, USA

The present research investigated whether transfer-enhanced learning can be used to promote transfer. More specifically, a repeated-cued-words test-retest method was used to enhance transfer and transfer of facts and concepts. Subjects studied prose passages and then either repeatedly restudied or took tests on the material. One week later, they took a final test that had either the same questions (Experiment 1a), novel questions within the same knowledge domain (Experiments 1b and 2), or novel questions from different knowledge domains (Experiment 3). Repeated testing produced superior retention and transfer as the final test relative to repeated studying. This finding indicates that the mnemonic benefits of over-enhanced learning are not limited to the retention of specific memory traces during initial learning but extend to the transfer of knowledge in a variety of contexts.

Keywords: testing, retrieval practice, transfer of learning, encoding variability, and recall
Exercise in repeatedly recalling a thing strengthens the memory.

Aristotle in Roediger & Butler, 2011
Wait. Isn’t retrieval just memorization?
How learning works
How learning works

1. Inputs from the environment
How learning works

1. Inputs from the environment
2. Attention
How learning works

1. Inputs from the environment
2. Attention
3. Information enters working memory
How learning works

1. Inputs from the environment
2. Attention
3. Information enters working memory
4. Encoding & processing leads to storage in long-term memory
How learning works

1. Inputs from the environment
2. Attention
3. Information enters working memory
4. Encoding & processing leads to storage in long-term memory

Memorization
Passive Learning
How learning works

Active learning

Retrieval
Effective encoding
Factual & procedural knowledge must be encoded & stored in long-term memory

Analysis
Accurate analysis of an unfamiliar prompt

Comprehension
Recognition that the correct knowledge is stored in long-term memory

Retrieval
Ability to effectively recall/pull that knowledge and get it into working memory

Cognitive Load
Have enough space in working memory to “work” the problem

Construct new meaning
Be able to construct new knowledge and ways of knowing by applying existing knowledge to new, unknown situations

Retrieval can be cognitively demanding
“It is firmly established that pulling information from memory enhances memory, strengthening it, and making it more readily available for complex tasks and future learning.”
If students will be asked to read and re-read on a test, that is how they should study.
If they will be asked to retrieve, they must practice doing so.
To help people learn, embrace the mindset that tests can cause learning and can be used as an active, deep learning strategy.
What are ways to help students learn using retrieval?

1. Engage them in repeated retrieval
2. Vary the types of retrieval
3. Provide feedback (explanatory and correctness)
4. Make it effortful
Insights From the Science of Learning Can Inform Evidence-Based Implementation of Peer Instruction

Julie A. Schell\textsuperscript{1,2,*} and Andrew C. Butler\textsuperscript{3,4}

\textsuperscript{1}Department of Educational Leadership and Policy, The University of Texas at Austin, Austin, TX, United States
\textsuperscript{2}School of Design and Creative Technologies, The University of Texas at Austin, Austin, TX, United States
\textsuperscript{3}Department of Education, Washington University in St. Louis, St. Louis, MO, United States
\textsuperscript{4}Department of Psychological and Brain Sciences, Washington University in St. Louis, St. Louis, MO, United States

Peer Instruction is a popular pedagogical method developed by Eric Mazur in the 1990s. Educational researchers, administrators, and teachers laud Peer Instruction as an easy-to-use method that fosters active learning in K-12, undergraduate, and graduate classrooms across the globe. Research over the past 25 years has demonstrated that courses that incorporate Peer Instruction produce greater student achievement compared to traditional lecture-based courses. These empirical studies show that Peer Instruction produces a host of valuable learning outcomes, such as better conceptual understanding, more effective problem-solving skills, increased student engagement, and greater retention of students in science majors. The diffusion of Peer Instruction has been widespread among educators because of its effectiveness, simplicity, and flexibility. However, a consequence of its flexibility is wide variability in implementation. Teachers frequently innovate or personalize the method by making modifications, and often such changes are made without research-supported guidelines or awareness of the potential impact on student learning. This article presents a framework for guiding modifications to Peer Instruction based on theory and findings from the science of learning. We analyze the Peer Instruction method with the goal of helping teachers understand why it is effective. We also consider six common modifications made by educators through the lens of retrieval-based learning and offer specific guidelines to aid in evidence-based implementation. Educators must be free to innovate and adapt teaching methods to their classroom and Peer Instruction is a powerful way for educators to encourage active learning. Effective implementation, however, requires making informed decisions about modifications.
Immediate Feedback Assessment Technique
To help people learn, embrace a pedagogy of retrieval.
It will help you and your students sleep well at night.
Acknowledgements

University of Groningen
Hans Beldhuis
Jaap Mulder
Koos Winnips
Irene Douwes-van Ark
Vincent de Boer

Cassandre Alvarado
Pooja Agarwal
Andrew Butler
Tamie Glass
Jeffrey Karpicke
Eric Mazur
Henry Roediger, III
Daniel Willingham
Veronica Yan
How to help people learn

Julie Schell
The University of Texas at Austin
Harvard University