



Testing Encourages Transfer Between Factual and Application Questions in an Online Learning Environment



Ruthann C. Thomas*

Hendrix College, United States

Christina R. Weywadt

University of New Mexico, United States

Janis L. Anderson

University of New Mexico, United States

Harvard University, United States

Brenda Martinez-Papponi

University of New Mexico, United States

Mark A. McDaniel

Washington University in St Louis, United States

Quizzing improves retention compared to additional study opportunities, a phenomenon known as test-enhanced learning. Two experiments investigated whether the type of question at quiz improves retention for factual and applied course material on exams in an online college course. Students were given quizzes with either factual questions or questions designed to encourage application of a particular concept. As expected, quizzing with feedback improved exam performance compared to material that had not been quizzed. Further, the benefits of quizzing transferred to different question types. Performance on application exam questions improved if students were quizzed with factual questions. Likewise, performance on factual exam questions improved if students were quizzed with application questions. These results replicate the finding that quizzing benefits retention in an online learning environment and, more importantly, that the benefits of quizzing transfer to exam questions that differ in type from the quiz question.

Keywords: Memory, Testing effect, Test-enhanced learning, Retrieval, Transfer

General Audience Summary

Extensive prior research suggests that quizzing experience in which students actively retrieve answers to questions bolsters their memory for the quizzed content more than restudying or simply reviewing the quizzed material. In the current experiments, we explored the utility of online quizzing with feedback for improving

Author Note

Ruthann C. Thomas, Department of Psychology, Hendrix College, United States; Christina R. Weywadt, Department of Psychology, University of New Mexico, United States; Janis L. Anderson, Department of Psychology, University of New Mexico, United States, Department of Psychiatry, Harvard University, United States; Brenda Martinez-Papponi, Department of Psychology, University of New Mexico, United States; Mark McDaniel, Department of Psychological & Brain Sciences, Washington University in St Louis, United States.

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* Correspondence concerning this article should be addressed to Ruthann C. Thomas, Hendrix College, Department of Psychology, 1600 Washington Avenue, Conway, AR 72032, United States. Contact: ThomasR@Hendrix.edu

performance on later exam questions that test the same concepts but in a different format, both in the response type (short-answer vs. multiple-choice) and the level of knowledge (factual vs. application of fact) required to answer the question. In two experiments, college students enrolled in an online neuroscience course were given quizzes with either factual questions or questions designed to encourage application of a particular concept, followed by an exam with factual and application questions on the concepts covered in the quizzes. Compared to concepts that were not covered on prior quizzes, students accurately answered more factual and application exam questions when they had previously answered quiz questions on the same concepts, regardless of whether those quiz questions were the same question type (i.e., both factual questions) or different question types (e.g., quizzed with factual question followed by an application exam question on the same concept). These results replicate the finding that quizzing benefits retention in an online learning environment and, more importantly, that the benefits of quizzing occur regardless of the type of quiz question. In sum, quizzing appears to benefit student understanding of concepts, thereby supporting its broad utility in educational contexts.

Quizzing improves learning by producing better long-term retention of quizzed content compared to restudied content (see [Carpenter, 2012](#); [Roediger & Karpicke, 2006](#); for reviews). *Test-enhanced learning* has been observed in laboratory studies ([Carpenter & DeLosh, 2006](#); [Karpicke & Roediger, 2008](#); [Roediger & Butler, 2011](#)), classroom settings ([Glass, 2009](#); [Glass, Brill, & Ingate, 2008](#); [McDaniel, Agarwal, Huelser, McDermott, & Roediger, 2011](#); [McDaniel, Thomas, Agarwal, McDermott, & Roediger, 2013](#); [Roediger, Agarwal, McDaniel, & McDermott, 2011](#)), and online college courses ([McDaniel, Anderson, Derbish, & Morrisette, 2007](#); [McDaniel, Wildman, & Anderson, 2012](#)). Accordingly, research supports the recommendation that educators can capitalize on test-enhanced learning by providing practice quizzes and tests to support students' retention of course material.

Less clear, however, is whether test-enhanced learning might also promote transfer of learning to related but nonquizzed questions in educational settings. Most laboratory demonstrations of test-enhanced learning use final test questions that are identical in wording to "quiz" questions (e.g., [Kang, McDermott, & Roediger, 2007](#)). However, college instructors report that they are hesitant to include test questions that are identical to previous quiz questions ([Wooldridge, Bugg, McDaniel, & Liu, 2014](#)). Further, if test-enhanced learning in educational contexts was restricted to repetition of identical quiz questions on summative tests (see, e.g., [McDaniel et al., 2011](#); [Roediger et al., 2011](#)), then performance gains due to testing might reflect rote memorization of correct answers for particular questions. For most educators, rote memorization of content is not the desired objective of instruction. Thus, current evidence supporting the benefits of testing does not directly align with how instructors might prefer to implement testing as a learning device in their classrooms.

To date, only a handful of studies have directly examined transfer of test-enhanced learning in authentic classroom settings ([Glass, 2009](#); [Glass et al., 2008](#); [Jensen, McDaniel, Woodard, & Kummer, 2014](#); [McDaniel, Anderson, et al., 2007](#); [McDaniel, Roediger, & McDermott, 2007](#); [McDaniel et al., 2012, 2013](#)), and the evidence is mixed. In one study conducted in a middle-school science class, results revealed limited transfer to exam questions that were different from quiz questions ([McDaniel et al., 2013](#)). Students were quizzed

in class (pre-lesson, post-lesson, and review) using a clicker response system with multiple-choice questions designed to either encourage application of learned content or retrieval of definitional knowledge. They received correct-answer feedback after each question. Although quizzing with application questions improved performance on definition exam questions relative to not quizzing that material, quizzing with definitions did not improve performance on application exam questions on the same content. Further, [Jensen et al. \(2014\)](#) demonstrated that students who took quizzes and exams with questions that emphasized deeper processing scored higher on both factual and application questions on a final exam than students who took quizzes that emphasized rote memorization. In a related experiment with college students with questions that required application of a fact, [Glass \(2009\)](#) observed transfer from quiz questions to exam questions when students took quizzes before, during, and after class. Across the quizzes, inference-based, multiple-choice quiz questions were either repeated or were different versions that tested the same content. Results showed that students performed better on inference-based exam questions when quizzed with different inference-based questions compared to the same repeated inference-based question. Together, these results demonstrate that both in-class and out-of-class quizzing produced transfer in a variety of classroom settings.

By contrast, [Mayer et al. \(2009\)](#) found that requiring college students to answer in-class quiz questions did not produce transfer to related exam questions (see also [Glass et al., 2008](#)). Results showed evidence for transfer to exam questions only when students completed quiz-like clicker sessions during in-class lectures that were accompanied by in-class discussions about why answers were correct or incorrect. Classroom applications of quizzing often do not include in-class discussions of answers (e.g., with on-line quizzing; [McDaniel et al., 2012](#); [Trumbo, Leiting, McDaniel, & Hodge, 2016](#); or with end-of-class quizzes; [Lyle & Crawford, 2011](#)). Thus, it remains important to determine whether the typical implementation of quizzing found in educational settings can enhance performance on exam questions.

The goal of the current experiments was to investigate whether taking pre-test review quizzes, with correct answer feedback but without classroom discussion of quiz responses

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