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The effects of prequestions on classroom learning

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DEDICATION

I dedicate my thesis to my family and friends. A special thanks goes to Nurun Begum who encouraged me to push on even during the tough times. This thesis, and this journey, would not have been made possible if not for you, my dear friend.

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ABSTRACT

Previous laboratory studies have shown that the use of prequestions (questions deployed prior to a learning episode) improves students' learning. The current study addressed whether these same effects would occur when using prequestions in a classroom setting. In a classroom study the effects of prequestions on immediate and on delayed retention were assessed where some students received questions before lecture (Prequestion Group) and other students did not (Control Group). To determine the immediate effects of prequestions all students were given an end of class quiz in which students in the Prequestion Group had to answer the prequestions as well as a never-before-seen question on material they covered in that day's lecture. Students in the Control Group had to answer two never-before-seen questions on material they covered in that day's lecture. Results from this experiment showed that within the Prequestion Group students did better on prequestioned material than on non-prequestioned material, replicating previous findings on the effects of prequestions. Additionally there was no difference in the learning of non-prequestioned material between the Prequestion Group and Control Group. On a delayed retention test students (both in the Prequestion and Control Group) did better on questions they saw before (on the end-of-class quiz) compared to questions they did not see before. This finding replicates findings from the testing effect literature. Students in the Prequestion Group, who saw one question both at the beginning and end of class, did not perform significantly better on this question on the delayed test compared to the question they only saw at the end of class. Overall these findings suggest that prequestions can improve learning of the prequestioned material without hurting the learning of non-prequestioned material. The

findings also suggest that retrieval practice improves the retention of material that was tested at the end of class compared to no test at all, but seeing a question before class added little benefit to this effect.

CHAPTER 1: INTRODUCTION

It should come as no surprise that most students have a natural desire to learn and do well in school. Both poor performing students, and those who excel in their classes, seek ways to improve their learning. Yet often students approach learning in sub-optimal ways. Recent studies that surveyed students' study habits have shown that students frequently do not choose the most beneficial study techniques (Karpicke, Butler, & Roediger, 2009; Yan, Thai, & Bjork, 2014). One potential way to improve students' learning is by having them use techniques that have been demonstrated to work. One well-studied method for improving students' learning is retrieval practice.

Benefits of retrieval practice

Retrieval practice refers to the beneficial effects of retrieval on memory. For example, students remember information better in the future if they retrieve that information on a test, than if they are simply re-exposed to the material such as through restudying it or rereading it. In the laboratory, Carpenter (2011) evaluated the impact of retrieval practice on learning. Participants in this study reviewed a series of word pairs in preparation for later testing. After an initial study phase, half of the participants were re-exposed to the word pair for restudy (restudy condition) whereas the other half was given a word prompt to recall the target word from each word pair (retrieval practice condition). Both groups were then tested after a short delay on the entire list of word pairs. Participants who engaged in retrieval practice performed significantly better on the posttest than participants who engaged in restudy. Similar findings have been reported in other laboratory investigations (Carpenter, 2009;

Carpenter & DeLosh, 2006; Pyc &Rawson, 2010; Roediger & Butler, 2011; Roediger & Karpicke, 2006; Rowland, 2014).

Previous studies have shown the benefit of retrieval practice in classroom settings as well. Carpenter, Pashler, and Cepeda (2009) examined memory for history facts in 8th grade students who reviewed a portion of the material through retrieval practice (i.e., active testing), through re-studying, or did not review the material at all. The investigators demonstrated that on a follow-up retention test conducted 9 months later, material reviewed via retrieval practice was remembered significantly better than material that was either restudied or not reviewed at all.

McDaniel, Wildman, and Anderson (2012) also explored the effects of retrieval practice in a classroom setting. Undergraduate students in a *Brain and Behavior* class were given weekly online review activities that differed by week: some weeks students were required to retrieve a target fact, other weeks they were asked to read the target fact, and during still other weeks the online review was skipped altogether. The authors found that the topics reviewed through retrieval practice were better remembered than either the topics reviewed through reading or those that were not reviewed.

Retrieval doesn't always improve retention

Although many studies have shown the benefits of retrieval in either the laboratory or the classroom setting, recent studies suggest that retrieval practice is not always the most effective learning strategy for all students. Carpenter, Lund, Coffman, Armstrong, Lamm and Reason (2016) asked undergraduate students in an introductory biology course to complete an in-class activity involving the topic of oogenesis. The students were assigned randomly to either a copy condition, in which they copied the definition of five terms, or a recall

condition, in which they recalled the definition of the five terms. Both groups were tested a week later on the five terms. In their analyses the authors divided each group into thirds on the basis of their class performance at the time of testing. They found that students whose overall class performance fell into the top third benefited more from the recall condition than the copy condition. However, students who fell into the bottom third did better in the copy condition than in the recall condition. Those who fell into the middle third performed equally in both conditions. The results suggest that retrieval practice is not always optimal for learning. In fact, certain types of students (e.g., low performing students) may actually fare relatively worse from retrieval practice.

Karpicke, Blunt, Smith, and Karpicke (2014) gave elementary school children an exercise covering science concepts on which the students initially only got 10% correct. They found that students who received retrieval practice did as poorly on a later test as students who received non-retrieval-based activities. As in the Carpenter et al. (2016) study, retrieval practice was found to be suboptimal for learning when initial performance was low. Both studies thus hint that retrieval practice might only benefit students who have prior knowledge of the material. If students have stored relatively little material to retrieve, which is typical of low-performing students, then retrieval practice may be no better than re-studying.

How to make retrieval more effective.

The research reviewed thus far suggest that a basal level of initial knowledge may be essential for retrieval practice to be effective. How then can one enhance the initial learning of material? One method for improving the initial encoding of material is through the use of prequestions. Prequestions are questions deployed before students engage in a learning episode. Research has shown that giving students questions on material they are about to

learn (i.e., prequestions) can improve future memory for that information (Hamaker, 1986; Rickards, 1977). It is possible, therefore, that prequestions can increase students' level of knowledge of a given topic, and lead to more effective use of retrieval practice.

Benefits of prequestions

Asking prequestions improves learning

In a typical laboratory experiment on prequestions, participants are divided randomly into a Prequestion Group, in which they receive prequestions to answer before reading a prose passage, or a Control Group, in which they are given only the passage to study to prepare for a later test. The usual findings are that the Prequestion Group performs significantly better on a delayed final test than the Control Group (Bull & Dizney, 1973, Boker, 1974; Little & Bjork, 2016; Peeck, 1970; Richland, Kornell, & Kao, 2009; Shanahan, 1986). Also, within the Prequestion Group, information that was prequestioned tends to be remembered better than other information from the passage that was not prequestioned (Bull & Dizney, 1973; Frase, 1968; Pressley et al., 1990; Richland et al., 2009; Rickards, 1976).

There is some suggestive evidence that prequestions might raise retention in lower-performing students more so than in higher-performing students (Memory, 1981; Memory, 1983). For example, Memory (1983) used the Gates-MacGinitie Reading Test to divide participants into the lowest (low-ability readers) and highest (high-ability readers) quartiles. Within each ability category, he assigned participants randomly to either a Prequestion Group or a Control Group. The author found that although both low- and high-ability readers in the Prequestion Group outperformed those in the Control Group on a final retention test, for the low-ability readers the difference between groups was twice as large as for high-

ability readers, showing that prequestions are especially beneficial for low-performing students.

Dowaliby (1990) explored the effects of prequestions and retrieval practice on learning in low- and high-ability readers. Participants at each ability level were assigned to one of three groups: Prequestion, Control, and Postquestion. The Postquestion Group functions as retrieval practice because here participants were required to retrieve information after a learning phase, but not before. Unlike Memory (1983), Dowaliby found that performance for low-ability readers on a final multiple-choice test over the prose passage was better in the Prequestion Group than in the Control Group, and this difference was similar for high-ability readers. He also found that performance for high-ability readers was better in the Postquestion Group than in the Control Group. Most importantly, however, Dowaliby found that low-ability participants in the Postquestion Group performed no better than those in the Control Group, whereas high-ability participants in the Postquestion Group did perform better than those in the Control Group, similar to the results reported by Carpenter et al. (2016).

Why do prequestions work?

As we have seen, prequestions can improve learning from reading passages. Furthermore, prequestions tend to benefit memory for the prequestioned information more so than for the non-prequestioned information. One idea to explain the memorial benefits of prequestions is that prequestions focus attention to prequestioned material (Bull, 1973; Frase, 1968; Hamaker, 1986; Hamilton, 1985; Shanahan, 1986). This idea predicts that participants receiving prequestions will perform better on final test items that repeat those questions than on items that test new material from the passage, because participants in the Prequestion

Group disproportionately focus attention on the prequestioned material when reading the passage. In support of this hypothesis, again studies have found that students who received prequestions performed significantly better on a delayed final test for prequestioned information than for non-prequestioned information (Boker, 1974; Frase, Patrick, & Schumer, 1970; Peeck, 1970; Sagaria & Di Vesta, 1978).

Do prequestions hurt learning of non-prequestioned information?

Several studies have compared learning of non-prequestioned material in the Prequestion Group and Control Group. Sometimes, it has been found that prequestions actually disrupt learning of non-prequestioned information (Boyd, 1973; Hamaker, 1986; Peeck, 1970; Shavelson, Berliner, Ravitch, & Loeding, 1974; Shanahan, 1986). Sagaria and Di Vesta (1978) showed this effect when they assessed memory for prequestioned and non-prequestioned information on an immediate final test. Participants in the Prequestion Group performed significantly better on prequestioned material than participants in the Control Group. However, the former participants performed significantly *worse* on non-prequestioned material than the latter participants, showing that exposure to prequestions had a detrimental effect on learning non-prequestioned material. The idea proposed earlier—that participants disproportionately focus attention on the prequestioned material, at the expense of the non-prequestioned material—is consistent with this reasoning. The negative effect of prequestions on non-prequestioned material could be due to learners in the Prequestion Group narrowing their attention to prequestioned material and possibly ignoring non-prequestioned material.

Prequestions with lecture material

The idea that learners can skip the non-prequestioned material to focus on prequestioned material may pertain specifically to learning of prose passages where readers are free to pace themselves through the reading. Here, learners can selectively decide which portions to focus on, and if they are inclined, which portions to ignore or skip. For other types of learning, such as students learning material in a lecture, prequestions may not have a detrimental effect on non-prequestioned information because it is less easy to skip over information. Here, the lecturer controls the pace of information presentation, which is not available to students all at once. Thus, in the case of learning from lectures or even video-recorded presentations, prequestions may not have a detrimental effect on learning of non-prequestioned information as they have sometimes been shown to do with reading passages.

Carpenter and Toftness (2017) explored the effects of prequestions on learning from video-recorded lectures in a controlled laboratory setting. In this experiment they gave students prequestions (the Prequestion Group) or no prequestions (the Control Group) prior to a video-recorded lecture on the history of Easter Island. Students in the Prequestion Group answered two short answer questions (e.g., How many families originally settled on the island of Rapa Nui?) prior to viewing each of three two-minute segments of the video, whereas students in the Control Group simply viewed the video without answering prequestions first. On a test immediately following the video, the Prequestion Group performed higher than the Control Group. The Prequestion Group also performed higher on questions that had previously appeared as prequestions (i.e., prequestioned information), compared to questions over the video that had not appeared as prequestions (i.e., non-prequestioned information). Interestingly, the Prequestion Group also performed higher than

the Control Group on the non-prequestioned information, suggesting that the presence of prequestions facilitated learning of other, non-prequestioned information from the video. This finding is opposite that of previous studies showing that the presence of prequestions sometimes harms learning of non-prequestioned information in studies using reading materials as stimuli (e.g., Boker, 1974; Frase, Patrick & Schumer, 1970; Peeck, 1970; Sagaria & Di Vesta, 1978). The positive effect of prequestions on learning from video presentations suggests that prequestions might have positive effects on learning from lecture presentations.

In the only known classroom study to explore the effects of prequestions, McDaniel, Agarwal, Huelser, McDermott, & Roediger (2011) explored middle school students' learning of science concepts by presenting multiple-choice in-class "clicker" questions at the beginning and end of each lesson. Though students' performance on the questions improved from pre- to post-lesson in two experiments, at the end of the lesson the prequestioned information was not remembered substantially better than non-prequestioned information from the same lesson (76% vs. 77% in one experiment, and 84% vs. 79% in another experiment).

McDaniel et al.'s (2011) study might suggest that prequestions are not beneficial for classroom learning. However, an important aspect of their design is that all of the students always received prequestions before each lesson. There was no control group that received only questions at the end of the lessons without having received prequestions first. The lack of difference in post-lesson performance between prequestioned and non-prequestioned information could mean that the presence of prequestions boosts memory for both prequestioned and non-prequestioned information relative to a situation in which no

prequestions were asked at all. Since there was no true control group, the effects of prequestions on lecture learning is unknown.

Another important question to explore concerns the long-term effects of prequestions. When a question is asked at the beginning *and* end of a learning event (i.e., prequestioned), as opposed to only at the end (i.e., non-prequestioned), how well are these concepts retained over time? Based on many studies of retrieval practice (Carpenter, 2012; Roediger & Butler, 2011; Rowland 2014), questions asked after some learning event would be expected to boost memory relative to a situation where questions are not asked. However, does previewing the question add to these benefits, such that the positive effects of retrieval are even stronger when retrieval practice is preceded by a chance to view the questions that will later be asked? In McDaniel et al.'s (2011) study, information that was questioned during class appeared on later reviews just prior to exams. On these reviews, information that had been asked at the beginning and end of class (i.e., prequestioned information) was remembered better than information that was asked only at the end of class (i.e., non-prequestioned information). However, again the study did not include a control group so it is unknown how these benefits compare to information that was never questioned in the first place, and the degree to which the placement of questions during class significantly boosts memory for the content being learned.

The current study explored the effects of prequestions on lecture-based learning. Advancing previous research on prequestions in the classroom, the study involved a Prequestion Group that received prequestions prior to each lecture, and a Control Group that learned the same content but did not receive prequestions prior to each lecture. The design thus allows a comparison of information learned from class as a function of whether or not

students received prequestions, and a measurement of the educational utility of prequestions as a learning tool.

CHAPTER 2: EXPERIMENT 1

Introduction

To address the influence of prequestions on classroom learning, retention of lecture content in an introductory psychology course was assessed. Students in the class were assigned randomly to a Prequestion Group, in which they were asked a lecture-specific prequestion before each class meeting, or a Control Group, in which they attended the same class without answering a prequestion first. At the end of each class, students in both groups were asked two questions pertaining to that day's lesson. For the Prequestion Group, one of these questions was the same as the prequestion (Prequestion), and the other question was a never-before-seen question from the same lesson (New Question). For the Control Group, both questions had not been seen before (New Questions). One week later, students were given a follow-up quiz in which they were asked these same two questions again, along with a third question that was covered in class the week prior but that had not been seen before (Quiz-Only Question).

This design allowed an exploration of the immediate effects of prequestions on lecture-based learning, by comparing performance at the end of class on the Prequestion vs. the New Question for both the Prequestion Group and the Control Group. It also allowed an exploration of the long-term effects of prequestions, by comparing one-week delayed memory for questions that appeared at both the beginning and end of class (Prequestions), vs. only at the end of class (New Questions), and how memory for this information compares to memory for information that was not tested at all (Quiz-Only Questions).

Hypothesis and predictions

Immediate effects of prequestions

Based on studies showing positive effects of prequestions (Carpenter & Toftness, 2017; Little & Bjork, 2016; Peeck, 1970; Pressley et al., 1990; Richland et al., 2009; Shanahan, 1986), it was expected that students in the Prequestion Group would learn more overall from the lecture than students in the Control Group. Also based on previous research, it was expected that within the Prequestion Group, memory for prequestioned information would be better than memory for non-prequestioned information (Bull, 1973; Frase, 1968; Hamaker, 1986; Hamilton, 1985).

Because class lectures do not allow selective processing of the material as much as reading passages, the effects of prequestions on non-prequestioned information would not be expected to be negative, as shown in previous studies (e.g., Boker, 1974; Frase, Patrick, & Schumer, 1970; Peeck, 1970; Sagaria & Di Vesta, 1978). Instead, no decrement, or even a possible advantage, for the non-prequestioned information in the Prequestion Group relative to the Control Group was expected (e.g., see Carpenter & Toftness, 2017).

Long-Term effects of prequestions

Based on many studies of the benefits of retrieval practice (Carpenter, 2012; Roediger & Butler, 2011; Rowland 2014), it was expected that content would be better remembered on the follow-up quiz if it had been tested at the end of class the previous week, compared to if it had not been tested. Thus, content from the Prequestions and New questions should be better remembered than content from the Quiz-Only questions, and this should apply to both the Prequestion Group and the Control Group.

Do prequestions boost the effects of retrieval practice?

McDaniel et al.'s (2011) study showed that material tested at the beginning and end of a lesson was remembered better on a delayed test than material only tested at the end of a lesson. Both types of materials were better remembered than non-quizzed materials. Taken together these finding suggest students do better on materials they have prior exposure to (e.g retrieval practice improves later performance) and that viewing questions as prequestions boosts these effects. Again, McDaniel et al.'s experiment did not have a control group that never received prequestions and so the effects of prequestions on delayed retention is still worth investigating.

It was hypothesized that students in both the Prequestion Group and Control Group would perform better on the delayed quiz for information that was tested at the end of class (New Questions) compared to information that was not tested at all (Quiz-Only Questions). Such a finding would be consistent with the well-known effects of retrieval practice (Carpenter, 2012; Kornell & Vaughn, 2016; Rowland, 2014). If prequestions boost the benefits of retrieval practice, then the retrieval practice effect (i.e., better learning for New Questions relative to Quiz-Only Questions) might be expected to be larger in the Prequestion Group than in the Control Group. Furthermore, within the Prequestion Group, the advantage in memory for Prequestions over Quiz-Only Questions would be expected to be greater than the advantage for New Questions over Quiz-Only Questions.

Method

Participants and course

The study was conducted in an introductory psychology laboratory course over two semesters. The course was taught by four graduate-level instructors and organized into small

sections of approximately 20 students each. Each instructor taught two sections of the course during one semester, and one section the following semester. Total enrollment across the 12 sections was 230 students.

Each section met once per week for 100 minutes and covered material pertaining to topics such as research design, sensation and perception, memory, and personality. The course content (including all PowerPoint slides, homework assignments, and projects) was prepared in advance by the faculty course coordinator, and was identical across all of the sections.

Materials and design

The study was designed to measure the effects of prequestions on both immediate and delayed retention of course content. To explore immediate retention, one group of students (the Prequestion Group) answered a question at the beginning of class pertaining to a concept that they would learn about in that day's class. The same question was repeated at the end of class, along with another never-before-seen question from the same lesson. The other group (the Control Group) did not answer any questions at the beginning of class, but instead answered two questions at the end of class. This aspect of the design is similar to previous studies exploring prequestions in laboratory-based research (Carpenter & Toftness, 2017). A comparison of performance on the end-of-class questions between the Prequestion Group and Control Group allowed a measure of the effects of prequestions on immediate retention of prequestioned and non-prequestioned information.

To explore the delayed effects of prequestions, a review quiz was given at the beginning of the next class period (one week later) containing the same two questions that students answered at the end of class one week prior, in addition to one never-before-seen

question from the same lesson. For students in the Prequestion Group, one of the three questions had been seen twice during class one week prior (once at the beginning of class, and once at the end), and one question had been seen only once (at the end of class). For students in the Control Group, two of the questions had both been seen at the end of class. A comparison of performance between questions asked at the end of class one week prior vs. questions not asked at all allowed a measure of the effects of retrieval practice on delayed retention of course concepts. A comparison of performance between questions asked at the beginning *and* end of class one week prior (i.e., prequestions) vs. only at the end, allowed an exploration of whether the effects of retrieval practice are enhanced by giving students a chance to preview the questions at the beginning of class.

This design required three questions to be constructed from each day's lesson. The questions required a short open-ended response, and were designed to cover independent concepts such that knowing the answer to one question would not give away the answer to another. All of the questions pertained to material that was presented directly in the instructors' PowerPoint presentations, oftentimes representing a term or definition (e.g., "What is procedural memory?") that was introduced and discussed that day.

For students in the Prequestion Group, one of the three questions was designated as the Prequestion, to be asked at the beginning and end of class (note that when this question was asked at the end of class it was called the Postquestion). Another question was designated as the New Question, which was asked only at the end of class. The last question was designated as the Quiz Only Question, which was asked only on the review quiz one week later. For students in the Control Group, two of the three questions from each class meeting were designated as New Questions, to be asked only at the end of class, and the third

question was designated as the Quiz Only Question. Thus, all students received two questions at the end of each class. The only difference was that the Prequestion Group saw one of these questions at the beginning of class and the Control Group did not. For all students, the same two questions from the end of class appeared, along with the Quiz Only Question, on the review quiz one week later. Figure 1 provides a schematic of the design for the first two weeks of the semester.

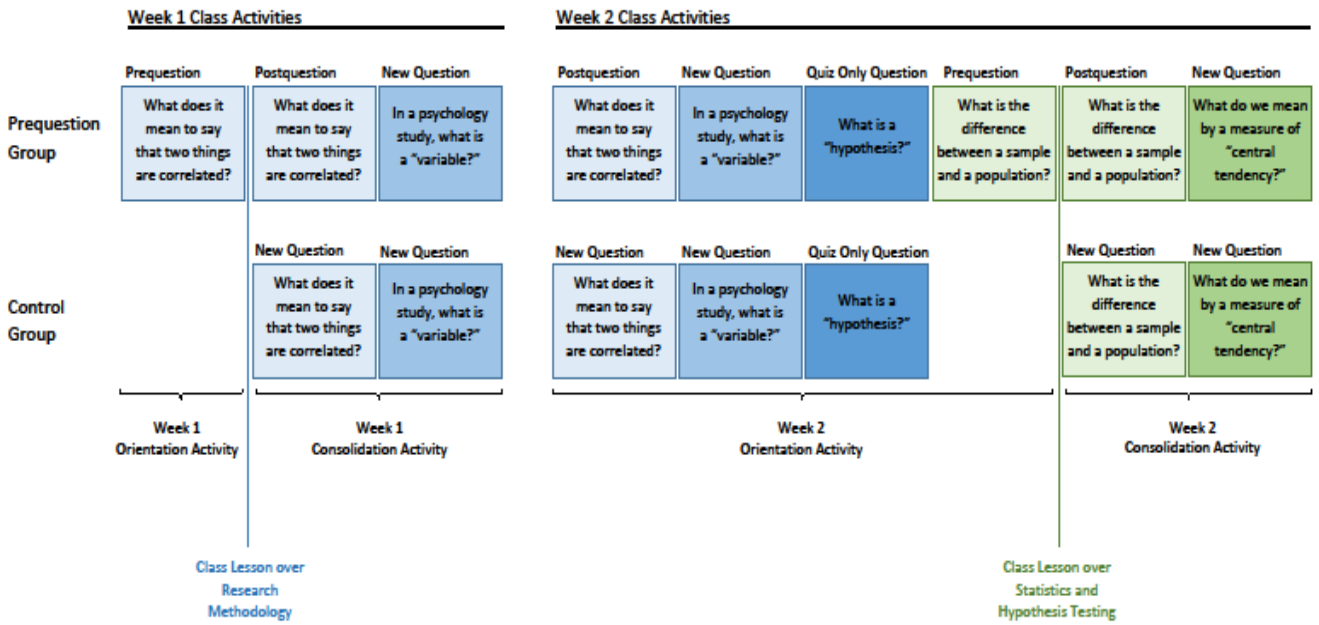

Figure 1. Class activities throughout the semester for the Prequestion Group and the Control Group.

For students in the Prequestion Group, six counterbalancing conditions were created so that each of the three questions from each lesson appeared equally often as the Prequestion, the New Question, and the Quiz Only Question. For students in the Control Group, three counterbalancing conditions were created so that each of the questions appeared equally often as New Questions and Quiz Only Questions. Within each class section, each

student was randomly assigned to one of the nine counterbalancing conditions. This way, any potential effects of the questions themselves were balanced across sections and instructors.

Procedure

Each class meeting involved answering questions at the beginning and end of class. These activities were introduced to students as "Orientation Activities" and "Consolidation Activities," respectively (see Figure 1). Students received participation credit for completing both activities, regardless of whether their answers to the questions were correct. For the first class meeting, the Orientation Activity required students to answer some questions about their interests in psychology, and for students in the Prequestion Group, to answer the prequestion pertaining to that day's topic. The Consolidation Activity at the end of class required all students (both Prequestion and Control Groups) to answer two questions pertaining to that day's lesson.

For each subsequent class meeting after the first, the Orientation Activities involved answering the three questions from the previous week's class. After answering these three questions, students in the Prequestion Group answered the prequestion pertaining to the upcoming lesson. This process was then repeated across subsequent class periods—the three questions from the previous week's lesson appearing at the beginning of class, followed by the prequestion over the upcoming lesson (for the Prequestion Group but not for the Control Group), followed by the instructor's lesson, followed by two questions at the end of class over the lesson that was just covered.

Students completed the Orientation and Consolidation activities on laptop computers that were provided. To complete the activities, students logged onto the online course

platform and were provided with a link that displayed the questions according to the counterbalancing condition to which they had been assigned. Instructions on the screen informed students that these activities were designed to help them learn the course content, and that they should try their best to answer the questions even if they were uncertain about the answers. The instructions also asked students to complete the activities individually, without help from books, notes, or classmates. The course instructors monitored the class during these activities to ensure that these instructions were followed.

Consistent with previous research on prequestions (e.g., Carpenter & Toftness, 2017; Little & Bjork, 2016; Richland et al., 2009), students in the Prequestion Group did not receive feedback after answering the Prequestion. Instructions on the screen informed students that they would be answering a question over a concept to be covered in that day's class. After submitting their answers to the prequestion, students were informed via instructions on the screen that the answer to the question would be provided during the lesson that day. On the Consolidation Activity at the end of class, students were informed via on-screen instructions that they would be asked some questions over the lesson that was just taught. After answering each of the two questions, one at a time, students were shown a screen with both of the questions and answers displayed together. They were permitted to view this screen as long as they liked, although students typically completed the Consolidation Activity in under five minutes. On the review quiz the following week, on-screen instructions informed students that they would be asked some questions about the previous week's lesson. Students answered each of the three questions, one at a time, without receiving feedback. Students in the Prequestion Group were then given the prequestion over the upcoming lesson, accompanied by the instructions that this question pertained to a

concept to be covered in that day's class. Thus, questions on the Orientation Activities never received feedback, whereas questions on the Consolidation Activities always did.

Access to the Orientation and Consolidation activities was only permitted during class. The online link to the Orientation Activity was made available at the start of class, and the instructors prompted students to complete the activity before they began teaching the lesson for that day. After students completed the Orientation Activity (which typically took under 10 minutes), the online link was no longer available, and the instructors proceeded with the lesson for that day. The link to the Consolidation Activity was made available toward the end of class. As soon as the lesson was complete, the instructors prompted the students to complete the Consolidation Activity. After class ended, the link to the Consolidation Activity was no longer available. Though the instructors' PowerPoint slides were shared on the online course platform after each class, the questions used in the Orientation and Consolidation Activities were not made available to students outside of class.

Our primary interest was on the effect of prequestions on lecture-based learning. Therefore, seven "target" class meetings were chosen that consisted primarily of lecture presentation, for which the homework assignments did not require direct use of the information from the Orientation or Consolidation questions. The other class meetings during the semester either consisted of hands-on activities without direct presentation of information from the instructors, and/or homework assignments that required use of the content from those lessons (e.g., drafting an APA-style paper from concepts learned in class). Focusing the analyses on the seven target classes allowed us to measure the effects of prequestions on retention of lecture-based information under conditions in which students were unlikely to receive additional exposure to that information outside of class.

For consistency, students completed the Orientation and Consolidation Activities at the beginning and end of every class. This routine was implemented over the first 12 weeks of the course, after which students worked on independent research projects for the remainder of the semester. Only data from the seven target class meetings were scored and analyzed.

Results

Scoring:

Data were analyzed for students who completed the course and completed at least one of the seven target classes of activities. Of the original 230 students enrolled, 5 students dropped the course, and two students did not complete enough activities to provide an analysis of at least one beginning, and end, of class activity. The following analyses are based on the remaining 223 students in the Prequestion Group (n = 150) and the Control Group (n = 73).

Students' responses to each question were scored as fully correct (2 points), partially correct (1 point), or incorrect (0 points). A scoring rubric was developed and applied in blind fashion by two independent raters to all of the responses from 58 students chosen at random (26% of the entire sample). In the Prequestion Group, the interrater correlations were positive for performance on the Prequestions at the beginning of class (r = .83) and at the end of class (r = .88), and for the New Questions at the end of class (r = .75). The correlations were positive as well for scores on the review quiz pertaining to Prequestions (r = .84), New Questions (r = .70), and Quiz Only Questions (r = .70). In the Control Group, correlations were positive for performance on the New Questions at the end of class (r = .84), and for New Questions and Quiz Only Questions on the review quiz (rs = .87 and .82, respectively).

All correlations were significant, *p*s < .001, so the remaining responses were scored in blind fashion by a single rater.

Performance was calculated based on the number of points earned on each of the question types (Prequestions, New Questions, and Quiz Only Questions), out of the total number of points possible per question type. For students who completed the beginning and end of class activities pertaining to all 7 topics, 14 points were possible for each question type (i.e., 2 points per question). For students who did not complete the activities for all 7 topics, scores were calculated based on the activities that they did complete, under the constraint that all in-class questions and review quiz questions were completed for a given topic. For example, if a student completed the in-class questions for Week 1, but missed the review quiz the following week containing questions from Week 1, no questions from Week 1 were included in any of the analyses. If a student completed the beginning of class activity but missed the end of class activity for a given topic, then no questions from that topic were included in the analyses. As such, only topics with a complete "question set" (i.e., receiving answers from students on all of the in-class questions and review quiz questions pertaining to that topic) were included.

The completion rate for the activities was fairly high. On average, students completed all of the activities for 6.18 topics (out of the total 7), and this completion rate did not differ between the Prequestion Group (M = 6.15, SD = 1.22) and the Control Group (M = 6.26, SD = 1.25), $t(221) = .65$, $p = .52$.

The effect of prequestions on immediate retention

Figure 2 shows the proportion of points earned on the in-class activities for both the Prequestion Group (n = 150) and the Control Group (n = 73). For students in the Prequestion

Group, performance on the prequestion improved significantly from the beginning of class to the end of class (see Prequestions vs. Postquestions, the two leftmost bars), $t(149) = 17.58$, $p < .001$, d=1.44. Students in the Prequestion Group also performed better on the Postquestions compared to the New Questions at the end of class, $t(149) = 3.73$, $p < .001$, d=.31, demonstrating that students who receive prequestions perform better at answering those same questions later, compared to new questions from the same lesson that they had not seen before.

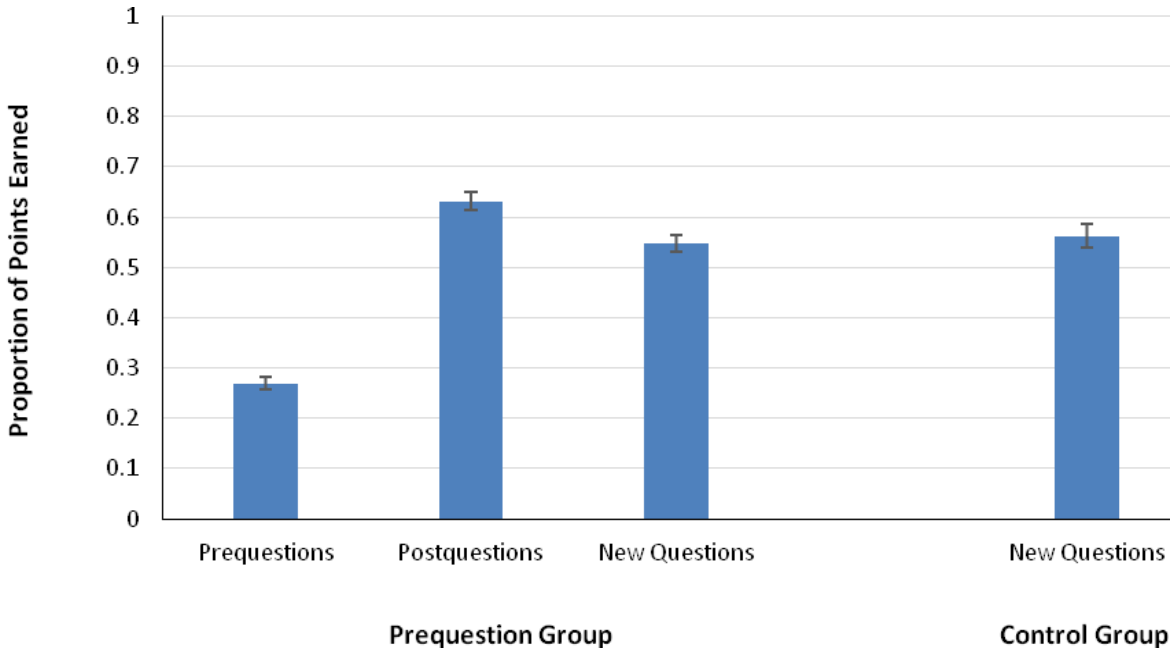

Figure 2. Proportion of points earned on the in-class questions for both the Prequestion Group and the Control Group.

To examine whether the effects of prequestions are general or specific, performance in the Prequestion Group for both prequestioned and non-prequestioned information was compared to performance in the Control Group. The Prequestion Group showed better performance than the Control Group for prequestioned information. That is, they performed

better on Postquestions than the Control Group did on New Questions, $t(221) = 2.29$, $p = .02$, d=.33. However, for non-prequestioned information (i.e., New Questions), there was no difference in performance between the Prequestion Group and the Control Group, $t(221) = .50$, $p = .62$, d=.07. It appears, therefore, that the benefits of prequestions applied only to prequestioned information, and did not spread to non-prequestioned information.

The effect of prequestions on delayed retention

Figure 3 shows performance on the review quiz for both the Prequestion Group and the Control Group. For this phase of the study two questions were of interest: (1) Does asking questions at the end of class enhance memory for course concepts, consistent with the benefits of retrieval practice? And (2) Do prequestions provided at the beginning of class boost this effect?

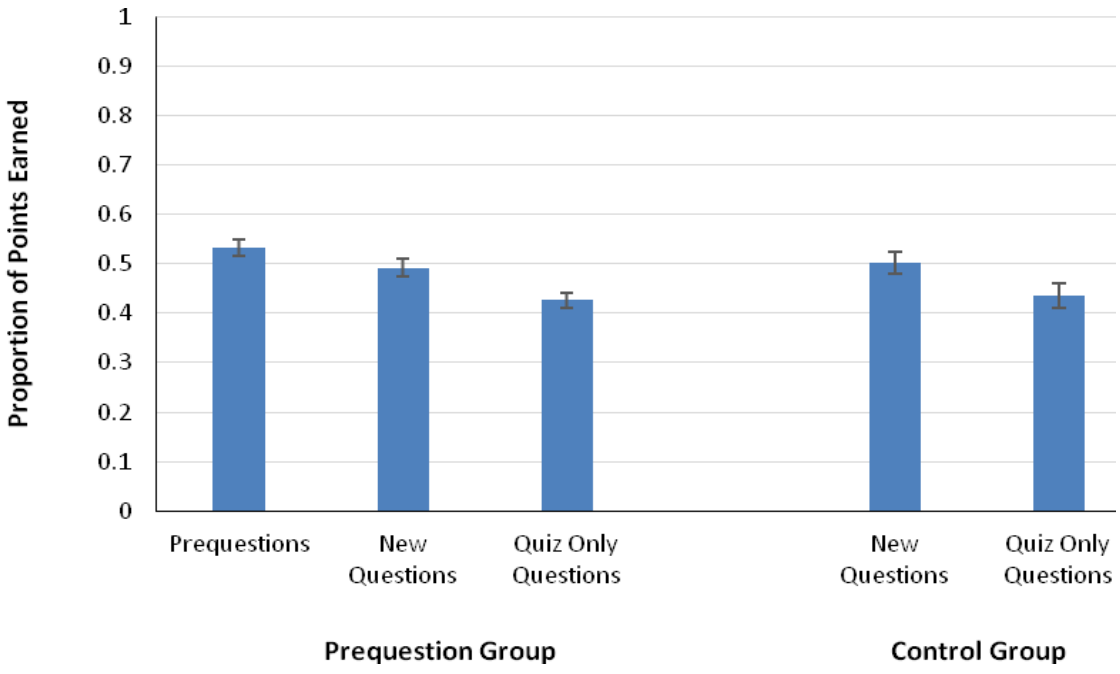

Figure 3. Proportion of points earned on the review quizzes for both the Prequestion Group and the Control Group.

The first question can be answered by comparing performance on the New Questions to the Quiz Only Questions. This difference was significant for both the Prequestion Group, $t(149) = 3.21$, $p = .002$, d=.26, and the Control Group, $t(72) = 2.91$, $p = .005$, d=.34. Thus, asking questions over a lesson at the end of class (and receiving feedback) significantly enhanced memory for those concepts one week later.

Is this effect enhanced by allowing students to preview the questions at the beginning of class? In the Prequestion Group, performance on the Prequestions was significantly higher than performance on the Quiz Only Questions, $t(149) = 5.73$, $p < .001$,d=.47, and was also higher than performance on the Quiz Only Questions in the Control Group, $t(221) = 3.18$, $p = .002$,d=.46. However, in the Prequestion Group performance on the Prequestions relative to the New Questions was only marginally better, $t(149) = 1.89$, $p = .06$, d=.15, and was not significantly better than performance on the New Questions in the Control Group, $t(221) = 1.02$, $p = .23$, d=.15. Thus, although asking questions at the end of class significantly boosted later memory for those concepts, previewing the questions at the beginning of class appeared to add little enhancement to this effect.

Discussion

This experiment was designed to explore the immediate and delayed effects of asking students prequestions before a lecture. To assess the immediate effects of prequestions, performance on end-of-class questions for students in the Prequestion Group (who received prequestions before the lecture) was compared to performance on end-of-class questions for students in the Control Group (who did not receive prequestions). It was predicted that students in the Prequestion Group would perform better for information that was prequestioned compared to information that was not prequestioned, and the results supported

this prediction. For information that was not prequestioned, however, students in the Prequestion Group did not perform better than students in the Control Group.

To explore the delayed effects of prequestions, students completed a follow-up quiz one week later to measure their retention of the previous week's lecture. It was predicted that information that had been tested at the end of class would be remembered better on the one week-delayed test relative to information that had not been tested, consistent with the effects of retrieval practice. This result emerged for both the Prequestion Group and the Control Group. However, it appears that prequestions did not boost the benefits of retrieval practice, evidenced by comparable performance on tested vs. non-tested information across the Prequestion Group and Control Group.

CHAPTER 3: GENERAL DISCUSSION

It is not uncommon for instructors to give a quiz to their students at the beginning of a class. These quizzes are usually given to determine how much their students know a given topic and can be used as an assessment tool to determine if students have come to class prepared (i.e., if they have done the assigned reading or the assigned homework). What is less known is how these quizzes affect students' learning from class. Most instructors may view pre-lecture quizzing as only an assessment tool, but research has shown that it is also a tool that can improve students' learning (Hamaker, 1986; Little & Bjork, 2016; Peeck 1970; Pressley et al., 1990; Richland et al., 2009).

Consistent with this finding, the current study found that students within the Prequestion Group (those who were given prequestions before the class lecture) did significantly better than students in the Control Group (those who were not given prequestions before the class lecture) on end-of-class questions over the lecture content. However, this benefit was specific to the information that appeared in the prequestions, and did not spread to non-prequestioned information. This result is in line with previous studies using reading passages as stimuli (Bull & Dizney, 1973; Frase, 1968; Pressley et al., 1990; Richland et al., 2009; Rickards, 1976).

Some studies have shown that students who are exposed to prequestions do significantly worse on non-prequestioned material than those who are not exposed to prequestions (Peeck, 1970; Rickards, 1977; Sagaria & Di Vesta, 1978). The current study, however, showed no such decrement. This could be explained by the processing that students engage in while learning from prequestions as a function of the learning material that they are exposed to. In studies using reading passages as stimuli, it is possible that prequestions

focus students' attention on the prequestioned information at the expense of the non-prequestioned information. When these passages are available to students to read at their own pace, this selective processing might result in skimming or ignoring passages of the text that are not relevant to the prequestions, resulting in worse memory for non-prequestioned information in a Prequestion Group relative to a Control Group.

During a class lecture, on the other hand, students do not know exactly when the prequestioned and non-prequestioned information will occur (as they are not themselves controlling the pace of the information delivery), so the decrement to non-prequestioned information may be less likely to occur. Furthermore, in an actual course setting (compared to a laboratory experiment), students may be more inclined to pay attention to the material, as they know that it will be important for class assignments and grades. Skimming or ignoring of non-prequestioned information under these conditions may be less likely to occur. In fact, given the assumption that course material is important for students to learn, one might argue that prequestions would enhance overall processing of the lecture information, resulting in a benefit on both prequestioned and non-prequestioned information. Though previous research using video-recorded lectures found this result (Carpenter & Toftness, 2017), the current study did not, and instead showed that the benefits of prequestions (over the Control Group) were specific to the prequestioned information.

One might ask why the Carpenter and Toftness (2017) study showed a general benefit of prequestions—on both prequestioned and non-prequestioned information—but the current study did not. Both experiments used a lecture like learning experience (where Carpenter and Toftness used a video lecture and the current study used a classroom lecture) and yet results from the two studies differed in that the former showed a general benefit of prequestions and

the latter did not. The discrepancy might be explained by the length of the lecture. In the Carpenter and Toftness study, students viewed a video that was only about 2 minutes in duration, whereas in the current study students attended a class lecture lasting about 100 minutes. It is very possible that the ability for students to sustain their attention over a learning episode depends on the length of that episode, such that attention is more likely to be allocated to the entire duration of a 2-minute video than a 100-minute lecture. In the latter, it is more likely that students attention will wane, their minds will wander, and they may become disengaged with the lecture material. When information specific to the prequestion is presented during the lecture, however, this information may be noticeable because students recognize it from the earlier prequestion. Memory for the prequestioned information may therefore be enhanced, but memory for the rest of the lecture—the non-prequestioned information—may not benefit when the lecture is fairly lengthy, due to the reasons described above.

Given the length of classroom lectures, it is therefore possible that the effects of prequestions may not be as strong in the classroom as they have been observed to be in laboratory studies. Indeed, the study by McDaniel et al. (2011) found only a modest benefit of prequestioned information over non-prequestioned information. Without a control group for comparison, it is unknown whether both types of information would be retained better compared to information retained by students who received no prequestions. The current study helps advance our understanding of prequestions in the classroom by showing that, relative to a control group, students who received prequestions did remember more at the end of class, but that this benefit was specific to prequestioned information.

With a control group, the current study also allowed an exploration of the effects of prequestions on retrieval practice. Consistent with the well-known benefits of retrieval (Carpenter, 2012; Dunlosky et al., 2013; Kornell & Vaughn, 2016; Rowland, 2014), students in the current study retained information from class on a one-week delayed quiz better if that information had been tested previously compared to if it had not been tested. Comparing delayed memory for information that had been tested at the end of class the previous week compared to information that had not been tested, this advantage was comparable across the Prequestion Group and the Control Group. Furthermore, the advantage in the Prequestion group was only marginally enhanced by providing prequestions at the beginning of class. These findings suggest that although retrieval is a powerful memory enhancer, providing prequestions at the beginning of class appears to add little additional benefit.

To the best of our knowledge, this is the first study to assess the effects of prequestions on classroom learning using a Prequestion Group and a Control Group. The results suggest that prequestions can help students retain information from lectures, but these benefits appear to be specific and are not extremely powerful effects. As mentioned above, it is possible that the benefits of prequestions are reduced when the duration of the learning material is long enough that students might have difficulty sustaining attention, or linking the information in the prequestion to the information presented in class. If so, prequestions may have limited benefits on realistic classroom learning. One way that these benefits could be improved might include reducing the duration of the content that follows the prequestions. Instead of asking one prequestion at the beginning of class, interspersing prequestions throughout class might be more likely to pique students' attention and result in greater benefits on learning (similar to the benefits of interpolated testing, e.g., Szpunar, Jing, &

Schacter, 2014). The effectiveness of prequestions might also be mediated by individual differences in students' curiosity, motivation, or prior knowledge.

Though the effects of retrieval practice have been well-established, the effects of asking students questions *before* they learn something is less well-understood. Research on prequestions suggests that these questions can improve learning for fairly brief durations of information in laboratory studies. Classroom studies on prequestions are uncommon, but the preliminary evidence from the current study suggests that prequestions can produce specific benefits on memory for prequestioned information, and might produce modest benefits on retrieval practice as well. These findings help advance the field by exploring the efficacy of a classroom technique for enhancing learning under ecologically valid conditions. More classroom-based research is encouraged that can optimize retention and comprehension of course content by asking students questions about what they are learning.

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