

DISCUSSION PAPER SERIES

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Performance of College Students**

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ABSTRACT

Incentives for Retrieval Practice and Exam Performance of College Students

Literature shows that retrieval of knowledge improves students' performance on exams (e.g., McDaniel et al. 2007; Roediger et al. 2011). In this study, we provide students in online and face-to-face Principles of Macroeconomics courses with practice questions that resemble the ones given on an actual exam and require a sample of the students to submit their answers. Then, we examine whether making the submission of the practice questions mandatory improves students' performance on actual exams. We find evidence that required submission of the questions for preparation for the first exam during the semester is associated with a higher score on these questions. The score students earn on the practice questions offered about a week before each exam (first, second and a final) is also positively related to the respective actual test grade. Additionally, better performance on each exam predicts a higher grade on the following exam(s), especially for online courses. The results indicate the importance of providing incentives for students to prepare for exams through retrieval practice.

JEL Classification: A20, A22, I21

Keywords: exam performance, principles of macroeconomics, test preparation, undergraduate teaching

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1. Introduction

It is well-known that practice helps students learn. Aristotle wrote that “exercise in repeatedly recalling a thing strengthens the memory.” Taking a quiz or exam requires recalling information, and therefore, promotes subsequent learning and retention of the material. Literature refers to this phenomenon of enhancing memory through retrieval practice as the “testing effect.”

However, given the time restraints in and outside the classroom and the large amount of material covered in most courses, students often find it challenging to recall information and to demonstrate their knowledge on formal exams. Literature has suggested various techniques to help students retain information. Practice quizzing has emerged as an effective retrieval-based strategy, especially when it is paired with free information recall (Bae et al. 2019). When done in class, practice quizzes have a positive effect on exam performance and have proven to be a powerful learning mechanism (Roediger et al. 2011). However, practice quizzing outside the classroom has mixed results. Voluntary chapter quizzes improve students' exam performance only when the best students choose to do the practice (Grimstad et al. 2004) or show no effect on performance (e.g., Galizzi 2010). On the other hand, mandatory, pre-class quizzes, have an overall positive impact on exam and class performance (Johnson et al. 2009).

This study extends the existing literature by exploring whether requiring that students submit an online quiz in the week before a formal exam improves students' actual exam performance. We collected data from five (three face-to-face and two online) sections of an introductory macroeconomics course at a four-year public university located in South U.S. Three of these five sections were assigned *optional* test preparation questions before the first exam during the semester, whereas the other two sections were *required* to submit their answers.

Submission of the practice questions offered before the second midterm and before the final exam was *required* for all five sections.

The results provide evidence that required submission of the questions for preparation for the first exam of the semester is associated with a higher score on these questions. Higher score on the practice questions is associated with a higher grade on the actual first exam. Additionally, better performance on the first exam predicts a higher grade on the second exam, and a higher grade on the second exam predicts better performance on the final exam, especially for online courses. The score students earn on the practice questions for each exam is associated with a higher grade on the actual test. This benefit is greater for online classes.

The rest of the paper is structured as follows. Section 2 presents the existing literature. Data and methodology are discussed in Section 3. Section 4 summarizes the results. Section 5 concludes the article.

2. Literature review

There is extensive literature that examines the effect of quizzes, or tests, on retention of information and class performance. The consensus is that these techniques are positively correlated with performance. McDaniel et al. (2007) find that quizzing, compared to reading, improves performance on critical tests. They also show that testing is an effective way to learn the material and assess the learning. Roediger et al. (2011) show that retrieval of information enhances learning even when feedback or the correct answers are not provided.

Dunlosky et al. (2013) provide a review of the different learning techniques, including practice tests, in psychology classes. Practice testing involves practicing recall of target information via online material, questions at the end of textbooks, or flashcards. Most studies

find a beneficial effect of in-class quizzing. Yet, Greving et al. (2018) who test the impact of in-class voluntary reviewing by allocating the last ten minutes of the class time to answering multiple-choice questions, short-answer questions, or writing summaries, find a positive effect of answering short-answer questions, but no impact of multiple-choice questions.

Practice quizzing outside the classroom has mixed results. While voluntary chapter quizzes improve testing only when the best students choose to do them (Grimstad et al. 2004), completion of mandatory pre-class reading quizzes is related to both better exam and course performance (Johnson et al. 2009).

The research on the impact of online quizzes on performance in economics classes is limited. Galizzi (2010) finds no improvement in exam performance for students who use optional online quizzes in introductory microeconomics and upper-level labor economics classes. On the other hand, Olczak (2014) shows that using web-based resources has a significant positive effect on student learning in a first-year microeconomics class that was offered optional ungraded web-based resources. Class attendance has also been shown to improve students' performance. For example, Marburger et al. (2006) find that a mandatory attendance policy significantly reduces absenteeism and improves exam performance. Chen et al. (2008) also find that attendance could improve grades by up to 18%.

Our study extends the existing literature to economics education. Specifically, we evaluate the effect of assigning students in principles of macroeconomics classes practice test questions that they are required to submit on actual test performance and compare these results with performance when submission of the practice questions is optional. In other words, we explore the effect of mandatory test preparation on exam performance. We also examine whether the aforementioned effects differ between online and face-to-face classes.

3. Data and methodology

Data were collected from five principles of macroeconomics classes taught face-to-face and online in a public teaching university located in the state of Georgia in Spring and Fall 2019. The same instructor taught all courses to eliminate any noise in the data associated with different teaching styles and activities chosen by different professors.

The sample consists of 204 students who completed two midterm exams and a final test. The instructor gave students an online study guide consisting of a set of practice test questions to complete during the week preceding each exam. To differentiate between the effect of a mandatory compared to optional preparation through retrieval practice, the submission of the practice test questions for the first exam was mandatory for only two of the five sections of the class. Submission of the practice questions proceeding the second midterm and the final exam was required for all sections. Each set of practice questions consisted of 65 to 80 multiple choice online questions that closely resembled the ones given on the actual exams. Students were allowed to attempt these questions five times and had three hours to complete them each time. They could also see the questions they had answered incorrectly after submitting their answers. In the instances where a student attempted a set of practice questions more than once, we utilize the highest score earned on that given set of practice questions for our empirical analysis.

We begin the analysis with a preliminary ordinary least squares specification to examine whether mandatory submission of the test preparation questions on the first exam is related to the performance of the students on each of the three exams:

$$ExamGrade_{mi} = \alpha + \beta MandatoryExam1Prep_i + \varepsilon_i \quad (1)$$

In this equation, *MandatoryExam1Prep* is an indicator showing whether submission of the practice questions before the first exam was mandatory (1 if yes, and 0, otherwise);

$ExamGrade_{mi}$ refers to the student i 's actual score (out of 100) on exam m (midterm exam 1, midterm exam 2, or final exam); and ε_i is an error term.

Then, we add the scores students earned on the practice questions for the respective exam as an additional predictor of the actual exam grade. For the second and the final exam, we also control for the actual and the practice questions scores on all previous exams. The reasoning is that students could perform better on each exam if they have better understanding of the preceding, related material. The regressions we estimate for each of the three exams are specified as follows:

$$ExamGrade_{mi} = \alpha + \beta MandatoryExam1Prep_i + \gamma Exam1PrepScore_i + Z_{mi} + \varepsilon_i \quad (2)$$

In eq. (2), for the second and the final exam, Z_{mi} includes the scores student i has earned on all previous actual exams and on the practice questions for exam m and the previous tests. This allows us to capture the possibility that understanding of previous material facilitates understanding of concepts covered later in the course, as well as the variation in the students' academic characteristics, including students' ability. It also allows us to minimize any bias that could result from students' self-selection into attempting the practice questions.

Finally, we conduct the analysis separately for face-to-face and online classes to explore whether the effects of interest differ across course delivery methods.

4. Results

Table 1 provides summary statistics of the entire sample and Table 2 differentiates between sections of the class that were and were not required to submit their practice questions for preparation for the first exam, as well as between class delivery methods (online versus face-to-face). About 45% of the students were required to submit their practice questions before the first exam. The average preparation scores students have earned on exam 1, exam 2 and the final

exam are 45.78, 73.37, and 78.97 (out of 100), respectively. The mean scores students have earned on the three exams are: 67.59% on exam 1, 74.40% on exam 2, and 64.72% on the final exam. About 38% of the students took the class online.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.
PrepExam1Grade	204	45.784	36.878
Exam1Grade	204	67.588	19.106
MandMT1prepQ	204	0.446	0.498
PrepExam2Grade	204	73.368	32.474
Exam2Grade	204	74.402	23.95
PrepFinalExamGrade	204	78.971	33.366
FinalExamGrade	204	64.721	28.66
Online	204	0.377	0.486

The summary statistics in Table 2 indicate that students who take the class in person on average perform better on all practice questions and actual exams, except the actual final test. Similarly, students who were required to submit the practice questions for the first exam also earned higher scores on all practice questions and actual exams, except the final test.

Table 2. Average scores on actual exams and pre-exam practice questions: by class delivery method and mandatory/optional submission of the pre-exam practice questions

	Face-to-face (N = 127)		Online (N = 77)		Optional exam 1 submission of practice questions (N = 113)		Mandatory exam 1 submission of practice questions (N = 91)	
	mean	sd	mean	sd	mean	sd	mean	sd
PrepExam1Grade	47.953	35.702	42.208	38.71	23.92	27.679	72.934	27.723
Exam1Grade	70.063	17.175	63.506	21.422	63.717	18.298	72.396	19.093
PrepExam2Grade	77.693	31.46	66.234	33.062	70.752	35.703	76.615	27.805
Exam2Grade	75.488	21.697	72.61	27.321	72.717	24.971	76.495	22.58
PrepFinalExamGrade	84.236	31.026	70.286	35.427	77.646	35.91	80.615	30.024
FinalExamGrade	62.717	24.886	68.026	33.903	70.717	28.627	57.275	27.049

In Table 3, we present the results from regressions whose goal is to examine whether mandating the submission of the practice questions for exam 1 and the score earned on these practice questions is related to the actual exam 1 grade of the students. We run specifications with: (1) only an indicator for mandatory submission of the prep questions (Column 1); (2) only the earned practice questions score (Column 2); and (3) the previous two explanatory variables

and an interaction term of the two (Column 3). Higher score on the practice questions prior to the first exam is associated with a higher exam 1 grade. The result is highly statistically significant. Although requiring submission of the practice questions is associated with a higher score on the first exam in a basic regression, the effect becomes statistically insignificant once we add the score earned on the practice questions and the interaction term. A simple regression of the binary variable indicating mandatory submission of the exam 1 practice questions on exam 1 practice questions score shows a highly statistically significant relationship between the two. These results suggest that mandating the submission of the preparation questions relates to a higher actual score on exam 1 through improved performance on the practice questions. The interaction term, when included, is positive but insignificant. This is intuitive, because one would expect that whether students prepare for an exam and how well they prepare would determine students' test performance, regardless of whether the preparation is required or not. However, requiring that they submit their preparation questions could make it more likely to prepare through retrieval practice.

Table 3. Preliminary regressions – Dependent variable: Exam 1 grade

	(1)	(2)	(3)
MandMT1prepQ	8.679*** (2.628)	-	-8.784 (5.505)
PrepExam1Grade	-	0.230*** (0.033)	0.235*** (0.058)
PrepExam1Grade *MandMT1prepQ	-	-	0.081 (0.087)
Obs.	204	204	204
R-squared	0.051	0.1973	0.209

*** $p < .01$, ** $p < .05$, * $p < .1$. St. error in parenthesis.

We also find that requiring the submission of exam 1 preparation questions is related to higher grades on exam 1 and exam 2, but not on the final exam (Table 4). The association is lower on exam 2 compared to exam 1. A more detailed analysis in which we take into account both performance on prior tests, preparation for them and practice for each exam, presented in

Table 5, shows that better performance on prior tests (exam 1 for exam 2, and exams 1 and 2 for the final exam) predicts a higher score on the respective exam. In addition, a higher score earned on the practice questions for each test is associated with a higher score on the actual exam and the effects are highly statistically significant. However, for exam 2 and the final exam, better performance on the practice questions for previous tests does not improve the actual grade on exam 2 and the final test.

Table 4. Basic regression of requiring the submission of exam 1 practice questions on actual exam grades

	Exam1Grade	Exam2Grade	FinalExamGrade
MandMT1prepQ	8.679*** (2.628)	3.778*** (3.371)	-13.442*** (3.935)
Obs.	204	204	204
R-squared	0.051	0.006	0.055

*** $p < .01$, ** $p < .05$, * $p < .1$. St. error in parenthesis.

Table 5. Effect of prior grades and preparation on current performance

	Exam1Grade	Exam2Grade	FinalExamGrade
Exam1Grade	-	0.666*** (0.067)	0.217** (0.094)
PrepExam1Grade	0.230*** (0.033)	-0.029*** (0.035)	-0.187*** (0.04)
Exam2Grade	-	-	0.668*** (0.087)
PrepExam2Grade	-	0.295** (0.038)	-0.164*** (0.053)
PrepFinalExamGrade	-	-	0.311*** (0.053)
Obs.	204	204	204
R-squared	0.197	0.560	0.602

*** $p < .01$, ** $p < .05$, * $p < .1$. St. error in parenthesis.

Finally, we perform a subsample analysis to explore differences in the aforementioned findings across groups of students. In Table 6, we focus on subsample analysis related to the first exam. The finding that requiring submission of exam 1 preparation questions is associated with a higher exam 1 actual grade is driven by face-to-face sections of the class. The positive relationship between the practice questions score and the actual exam grade is greater when submission of the preparation questions is required. When mandatory, the same association is greater for online classes.

Table 6. Subsample analysis – Dependent variable: Exam 1 grade

	(1)	(2)	(3)	(4)	(5)	(6)
MandMT1prepQ	-	-	10.216***	6.770	-	-

			(2.950)	(4.863)		
PrepExam1Grade	0.317*** (0.065)	0.235*** (0.059)	-	-	0.217*** (0.076)	0.387*** (0.110)
Sample	Mandatory exam 1 submission of prep questions	Optional exam 1 submission of prep questions	Face-to- face	Online	Mandatory exam 1 submission of prep questions, Face-to-face	Mandatory exam 1 submission of prep questions, Online
Class section effect	No	No	No	No	Yes	Yes
Obs.	91	113	127	77	55	36
R-squared	0.211	0.127	0.088	0.025	0.133	0.266

*** $p < .01$, ** $p < .05$, * $p < .1$. St. error in parenthesis.

We extend the subsample analysis to exam 2 and the final test in Table 7. The results are consistent with the previous findings presented in Table 5. Specifically, for both exam 2 and the final test, performance on the previous exams is associated with a greater score on each of the following tests. Performance on exam 1 is a better predictor of students' grade on the second exam for online courses compared to in-person ones, and performance on the second exam is a better predictor of the grade on the final exam for online courses as well. However, for online courses, the grade on the first exam is not statistically significantly related to the score on the final exam. We also find that the association between the preparation score for exam 2 and the actual exam 2 grade is greater for online courses. The same is true for the relationship between the score earned on the practice questions for the final exam and the final exam actual grade. All of these results are highly statistically significant.

Table 7. Subsample analysis for Exam 2 grade and Final exam grade, by course delivery method

	Exam2Grade	Exam2Grade	FinalExamGrade	FinalExamGrade
Exam1Grade	0.599*** (0.096)	0.769*** (0.091)	0.311*** (0.112)	0.211 (0.156)
PrepExam1Grade	-0.014 (0.046)	-0.066 (0.053)	-0.259*** (0.047)	-0.137** (0.067)
Exam2Grade	-	-	0.581*** (0.102)	0.646*** (0.152)
PrepExam2Grade	0.252*** (0.049)	0.396*** (0.058)	-0.104* (0.060)	-0.186** (0.093)
PrepFinalExamGrade	-	-	0.23*** (0.064)	0.479*** (0.087)
Sample	Face-to-face	Online	Face-to-face	Online
Obs.	127	77	127	77
R-squared	0.4573	0.7115	0.5741	0.7297

*** $p < .01$, ** $p < .05$, * $p < .1$. St. error in parenthesis.

5. Conclusion

This study examines the association between exam preparation and performance on the actual tests. Using data collected from principles of macroeconomics classes, this study finds that requiring that students submit their answers to the practice questions provided for the first exam of the semester improves their score on these submitted preparation questions. This is important because a higher score on the practice questions is associated with a higher grade on the actual first exam, especially for online classes when submission of the preparation questions is required. In addition, higher score on the first exam predicts a higher score on the following tests, and a higher score on the second exam predicts a higher grade on the final exam. These findings are driven primarily by online classes. There is also a positive association between the preparation score before exam 2 and the actual exam 2 grade, as well as between the preparation score before the final exam and the actual final test grade. The latter relationship is greater for online compared to face-to-face classes.

These findings highlight the importance of requiring students to submit the work they perform to prepare for exams, because their performance earlier in the semester also improves performance on later exams. Requiring that students show their work is especially important for online classes although all students regardless of course delivery method could benefit. Future research is needed to explore differences in the effect of exam preparation on performance for different demographic groups, higher level economics courses, and other disciplines.

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