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Online quiz time limits and learning outcomes in economics

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ABSTRACT

In an effort to better understand the impact of timing limits, the authors compare the learning outcomes of students who completed timed quizzes with students who took untimed quizzes in economics principles courses. Students were assigned two online quizzes—one timed and one untimed—and re-tested on the material the following class day. Our findings indicate that time limits do not significantly alter student learning. Thus, the decision of placing time limits should be based on factors (e.g. cheating, student preferences, etc.) other than student learning outcomes.

Keywords: On-line assessment; time limits; assessments; economic education; timed quizzes.

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Introduction

Much of the research regarding the effects of time limits on scholastic achievement aims to determine whether a time limit on an assessment affects student grades on said assessment. Researchers have not typically analyzed the effects on students learning *after* the assessment is completed. While students likely learn very little on a closed-book in-class exam, there are certainly reasons to believe that online quizzes, where students are allowed to use textbooks and notes, don't just assess skills; rather, these quizzes *cause* student learning. Thus, the appropriate question is not "Does a time limit on an online quiz affect scores on the online quiz"? Instead, this paper addresses a more compelling research question: "Do time limits for online quizzes affect student knowledge following the quiz?" In doing so, one can gauge the longer term impacts of the timing mechanism used on online quizzes.

There are two key aspects to student learning: 1) Accumulation of knowledge and 2) Retention of accumulated knowledge. Untimed online quizzes reward students who accumulate enough information to successfully answer specific quiz questions. If the student has not prepared enough or does not recall a piece of information, the student has time to carefully search her notes, textbook, or other materials until she finds the answer. The student's accumulation efforts are rewarded with a better quiz score. In the process, the student accumulates potentially vast amounts of information. For this reason untimed quizzes may be a very good method of instruction under the following circumstances:

1) The desired learning outcome can be focused using targeted quiz questions.
2) Students feel the reward justifies the extra effort required to search for the solution.
3) Students retain the knowledge accumulated.

Whether each of these conditions is met varies, depending upon the course and the nature of the material. The first condition might be impractical depending upon the subtleties of the material. The second depends upon the motivation of the student and the impact of each question on the student's grade. This last condition is potentially the most troublesome. Students may accumulate enough information to choose the correct answer without understanding why the answer is correct. The student may also have simply searched for a similar example to the question asked without effort to retain the knowledge accumulated.

Timed quizzes, as a result of their short duration, do not reward students to accumulate more knowledge during or after the quiz. Therefore, students must try to anticipate what material will be covered by the quiz and prepare accordingly. If students have not adequately prepared, they will likely be unable to search for the correct answer *during* the online quiz due to the succinct allotted time. Thus, they have no short term incentive to accumulate additional knowledge. However, they do have incentive to expend effort to retain the information, at least long enough to answer the questions on the quiz, since they cannot obtain this information quickly enough once the quiz has begun. For this reason timed quizzes may be a very good method of instruction under the following circumstances:

1) The desired learning outcome is broader than can be effectively quizzed.
2) Students feel the expected reward to studying a particular piece of material is worth the effort even given the uncertainty of which questions will be asked.
3) That the students can retain the information longer than just for the quiz.

Whether the totality of the information collected and retained long enough to be recalled the next day is greater for the timed or the untimed quiz is the purpose of this paper.

However how much knowledge is accumulated and how much is retained is strongly influenced by student effort. The authors use the approach of Devadoss and Foltz (1996). Student utility is given by U = U(C, R, E) where C is a composite consumption good, R is leisure and E is educational performance. Educational performance is a production function E = E (S, X, Z) where S is the time spent on education, X is a vector of inputs such as books, housing, etc.; and Z is a vector of endowment factors such as motivation, cognitive and innate skills, and other factors including the instructor's teaching skill, and other course related factors. This implies that students balance work and leisure when making the choice of how much time to devote to their studies and that students will seek to economize their efforts.

Part of the importance of the issue of timed versus untimed online quizzes is that it may be an effective method of controlling cheating. Watters et al. (2011) found that among those surveyed, 61% of students believed that timed online exams would be effective in discouraging cheating—only 14% believe this would be ineffective and 25% provided no opinion. If timed online quizzes are an effective method of controlling cheating, then knowing whether this method will negatively impact student performance is critical. Conclusive evidence supporting either timed or untimed quizzes could provide a simple, practically costless, outlet for improving student learning outcomes and preventing cheating. Implementing time limits is usually as simple as clicking a radial button in an online testing portal.

Literature Review

The literature regarding timed/untimed quizzes is sparse, but there are a few examples. One avenue of research in timed versus untimed performance focuses on the issue of test anxiety. An early paper (Morris and Liebert 1969) found that those with high-worry tended to perform more poorly when timed. More recent work by Tsui and Mazzocco (2006) found that math anxiety negatively impacted performance when a timed exam is given to math anxious students; however, this impact disappeared when the timed exam was given after an untimed exam. Onwuegbuzie and Seaman (1995) tested the impact of timed and untimed exams on statistics students. They found that the performance of each group improved on the untimed exams; furthermore, they found math anxious students' grades improved more than other students'. Kellogg, Hopko and Ashcraft (1999) examined timed versus untimed exams on mathematics students. Similar to the results found by Onwuegbuzie and Seaman, they found that both math anxious and non-math anxious student performance improved on untimed exams; however, unlike Onwuegbuzie and Seaman, they found no difference in the improvement between the anxious and non-anxious groups. Likewise, a comprehensive, primary school study found that time restraints typically did not correlate with performances on standardized tests (Brooks et al. 2003). However, when time was a factor, middle and high school students with no time constraints outperformed those who were timed. Lesaux, Pearson, and Siegal (2006) found that when those with reading disabilities were given timed exams, the performance difference between those with normal reading abilities and those with less severe reading disabilities was significant. These differences disappeared when the exam was untimed.

In online economics and business courses, Calafiore and Damianov (2011) and Damianov et al. (2009) show that students who spend more time online, utilizing course material, perform better on exams. Likewise, Maclean and McKeown (2013) find that time spent on online quizzes is strongly correlated with performance in an

economics principles course. Most of the literature shows either no difference between online and traditional assignments or support for the effectiveness of online materials. However, Aljamal et al. (2015) report conflicting evidence. The authors randomly selected students to participate in online assignments throughout macroeconomics principles courses. They find the completion of these assignments, as well as the duration of time spent working on these assignments, has no bearing on student performance on exams. The merit of online assignments is debated, but its prevalence in economic education has increased, in part, due to the ease of use. While McKeown and Maclean (2013) report that online quizzes are take-home assignments are equally effective, they suggest that online assignments take less time to grade and provide more immediate feedback to students and are thusly superior to traditional assignments. In addition, online materials allow for more flexibility as students can take online quizzes anywhere and at any time (Macgregor and Turner 2009).

The only paper that explicitly examines how timed versus untimed quizzes might have disparate impacts on student performance on later course materials is Brothen and Wambach (2004). Participants obtained from two different sections of the same class took timed or untimed quizzes. One section was given timed quizzes and the other untimed quizzes. Not being able to control for potential differences between these two section populations is a serious limitation of the Brothen and Wambach approach. While the sophistication of the statistical analysis is questionable, some teachers/researchers have used this study as a guideline for quiz development (e.g. Dobson 2008; Marcell 2008) because they found strong evidence that time limits improved performance in Psychology of Human Development courses. The section given fifteen minute time limits on ten question quizzes performed better on those quizzes, achieved faster quiz completions, and higher future exam scores.

Method

Data

The data include students from four classes. Two of these classes were Principles of Macroeconomics, taught by Dr. Brent Evans. The other two classes were Principles of Microeconomics with Dr. Robert Culp. Both of these classes are required for students majoring in any business course at Dalton State College, a four-year regional college in extreme northwest Georgia.

The data collection process included a pre-test, a survey, two online quizzes, and two in-class quizzes for students in the four courses. The survey, which was administered on the second class day of each class includes questions on demographics, prior course completions, and other pertinent information. Questions from the survey were used to create the variables *age, white, male, employed,* and *ftstudent*. Variable descriptions and summary statistics for all variables, including these survey variables, can be found in Tables 1 and 2, respectively.

Table 1.
Variable Descriptions

Variable	Description
inclass1	Score on first in-class quiz, standardized
inclass2	Score on second in-class quiz, standardized
online1	Score on first online quiz, standardized
online2	Score on second online quiz, standardized
timed1	Equals 1 if online quiz 1 was timed
timed2	Equals 1 if online quiz 2 was timed
quizavg	Average on all online quizzes prior to "Online1"
quizavgplus	Average on all online quizzes prior to "Online2"
quizmissed	Quantity of online quizzes unattempted prior to *InClass1*
quizmissedplus	Quantity of online quizzes unattempted prior to *InClass2*
morning	Equals 1 if student is in morning class
econliteracy	Score on 20 question economics quiz prior to class, standardized
mathliteracy	Score on 20 question math quiz prior to class, standardized
age	Age, in years
white	Equals one if student self-identified as white
male	Equals one if student self-identified as male
employed	Equals one if student self-identified as employed, part time or full time
ftstudent	Equals one if student self-identified as a full-time student

Table 2.
Summary Statistics

Macroeconomics							Microeconomics				
Variable	n	Mean	Std. Dev	Min	Max		n	Mean	Std. Dev	Min	Max
inclass1	56	0	1	-3.44	1.43		36	0	1	-2.51	2.77
inclass2	46	0	1	-1.88	1.81		34	0	1	-1.88	2.05
online1	56	0	1	-2.23	1.62		36	0	1	-2.55	1.69
online2	49	0	1	-3.91	1.36		38	0	1	-1.71	1.84
timed1	71	0.45	0.50	0	1		49	0.49	0.51	0	1
timed2	71	0.55	0.50	0	1		49	0.51	0.51	0	1
quizavg	72	0	2.68	-7.21	5.72		49	0	4.57	-10.44	8.38
quizavgplus	72	0	3.34	-9.09	5.5		49	0	7.06	-14.04	15.02
quizmissed	72	0.90	1.31	0	4		49	1.18	1.63	0	6
quizmissedplus	72	1.65	2.22	0	7		49	2.82	3.31	0	11
morning	72	0.67	0.47	0	1		49	0.612	0.49	0	1
econliteracy	72	0	1	-2.26	2.46		49	0	1	-2.02	2.52
mathliteracy	72	0	1	-2.37	2.01		49	0	1	-2.45	2.39
age	71	22.08	4.06	18	38		49	22.22	5.4	18	43
white	71	0.68	0.47	0	1		49	0.71	0.46	0	1
male	71	0.56	0.50	0	1		49	0.63	0.49	0	1
employed	71	0.93	0.45	0	1		49	0.82	0.39	0	1
ftstudent	72	0.82	0.38	0	1		49	0.78	0.42	0	1

Immediately following completion of this survey on the second day of class, students attempted a pre-test containing 20 math and 20 economics questions. Students were given two free points on a future test for taking the pre-test and were also provide

one free point on a future quiz for all questions answered correctly.[1] These questions were selected from the economics, geometry, and algebra end-of-course tests utilized by the Georgia Department of Education for students to take following completion of these high school courses.[2] Of the twenty economics questions, students in Macroeconomics averaged 11.2 correct answers compared to an average of 12.4 correct answers in Microeconomics. Of the twenty math questions (ten from algebra and ten from geometry), an average of 7.0 were answered correctly in both Macroeconomics and Microeconomics.

The second phase of the project was the online and in-class quizzes. Throughout the semester, students engaged in online quizzes using Aplia software, which is typical practice in our principles courses. Students were made aware that some quizzes would divide the class such that half the students would be assigned timed (30 minute maximum) quizzes and the other half would be assigned untimed quizzes. By the end of the semester, all students would receive the same quantity of timed and untimed quizzes. The online quizzes contained 18 questions—all students were asked the same question. The untimed quiz could be completed at a student's leisure. Quizzes were posted immediately following class Monday morning and were due at 11:45 PM that night.[3] In Macroeconomics, the first online quiz (covering Keynesian economics and related concepts) yielded an average score of 66.3%. The average score on quiz 2—covering fiscal policy and the Great Recession—was a 79.9%. The class was divided such that half of the students had the first quiz timed and the other half completed the second exam with a time constraint. The same method was used in Microeconomics. For the two online quizzes used, the averages were 64.5% (Elasticity and related concepts) and 51.0% (Competitive Firm Behavior). Table 3 depicts the scores on each of the online quizzes, comparing the students who were given time limits to those who were not. Online quiz grades do not significantly differ between those who took the quiz with a time limit compared to those who had no time limit.

Table 3.

Comparison of timed/untimed online quizzes

Class	Variable	Timed	Untimed	P-Value
Macro	*Online1*	0.133	-0.107	0.378
	Online2	-0.073	0.093	0.559
Micro	*Online1*	0.039	-0.039	0.643
	Online2	0.025	-0.025	0.761

This study does not aim to analyze the effects of timing on the online quiz grade results. Rather, it examies whether students retention of the material was influenced by the timing of the online quiz. In order to proxy student retention of the material, in-class "pop" quizzes were administered at the beginning of the class period immediately following the online quizzes. Students were made aware that there would be four pop quizzes throughout the semesters. Each quiz (online and in-class) was worth about 1% of a student's final grade. These in-class quizzes covered similar content, but no questions were repeated. These in-class quizzes also contained 18 questions. The averages for the in-class quizzers were 77.2% and 69.9% in Macroeconomics and 56.2% and 62.3% in Microeconomics.

[1] Students were allowed to opt-out of the study and still receive bonus points. Furthermore, students under the age of 18 were not allowed to take part in the study but were still allowed to attain bonus points.

[2] Algebra and Geometry end-of-course tests are no longer utilized in Georgia, which now administers comprehensive math courses (e.g. Mathematics 1, Mathematics 2, etc.).

[3] There was some concern that employed students working night shifts would not have time to complete the quizzes. Students were allowed to take the quiz early if they wished. No students requested early posting.

Econometrics

Using ordinary least squares, the authors create four simple regressions. The dependent variable for each regression is the standardized performance on each of the in-class quizzes *(inclass*$_1$ and *inclass*$_2$). The regression is specified as:

$$inclass1_i = \beta_0 + \beta_1 timed1_i + \beta_2 X_i + e_i$$

where $timed1_i$ is a dummy variable indicating whether the student took an online quiz that was timed or timed and X_i is a vector of student-level control variables. The error term is represented by e_i. Four regressions are constructed since there are two courses (Principles of Microeconomics and Principles of Macroeconomics) and two quizzes for each course (*inclass1* and *inclass2*). By regressing in-class quiz scores on the online quiz timing mechanism, one can directly examine whether the in-class quiz grade is influenced by design of the online quiz (timed vs. untimed) after controlling for other relevant variables.

Results

The regressions results for Principles of Microeconomics are provided in Table 4. As indicated, performance on the in-class macroeconomics quizzes is not significantly correlated with many of our control variables. In fact, no single variable is relevant in both regressions. For the first in-class quiz (Inclass1), performance on the 20 math questions administered at the beginning of the semester (mathliteracy) is positively correlated with in-class quiz results—a one standard deviation increase in performance on the math quiz is correlated with a 0.362 standard deviation increase in in-class quiz grade. This is not surprising since the first in-class quiz was math-intensive. The variables *employed* and *ftstudent* are both negatively correlated to *Inclass1*—full-time students and students with jobs were outperformed by their peers. The timed dummy variable (timed1) is positively correlated with performance on the in-class quiz, but the result is not significant.[4]

Table 4.
Macroeconomics Regressions

	Dependent Variable: *inclass1* (n=44)			Dependent variable: *inclass2* (n=36)		
Variable	Coefficient	|t|	P > |t|	Coefficient	|t|	P > |t|
Intercept	0.150	0.17	0.870	2.154	1.68	0.106
timed1	0.257	1.06	0.295	-	-	-
quizavg	0.076	1.60	0.118	-	-	-
quizmissed	0.139	0.86	0.396	-	-	-
timed2	-	-	-	-0.654	1.76	**0.091**
quizavgplus	-	-	-	0.083	1.80	**0.084**
quizmissedplus	-	-	-	-0.539	1.37	0.184
morning	-0.034	0.12	0.908	-0.074	0.38	0.709
econliteracy	-0.024	0.17	0.866	0.238	1.48	0.152
mathliteracy	0.362	2.85	**0.008**	-0.063	1.46	0.159
age	0.031	1.01	0.320	0.393	1.01	0.322

[4] For each in-class quiz, alternative regressions were constructed that included a control variable for the score on the online quiz. This did not substantially alter regression results. Additionally, regressions that included an interaction term for *male* and *timed*, to account for the possibility that time limits may affect genders differently (Tsui and Mazzocco 2007), did not yield differing results.

white	0.368	1.31	0.201	0.171	0.46	0.651
male	-0.242	0.93	0.358	-0.191	0.51	0.613
employed	-0.818	2.92	**0.006**	-0.050	0.12	0.905
ftstudent	-0.630	1.84	**0.074**	-0.120	0.78	0.441

The second regression, also depicted in Table 4, includes the same classes, but the timed/untimed component for each student is switched—students who took the first online quiz timed had no time limit for the second online quiz. In this regression, *Quizavgplus* (average quiz score prior to the online quiz of interest) is significant—an expected result. While the "timed" dummy variable is not significant for *InClass1*, it is marginally significant for *Inclass2*—taking the online quiz with a time limit is correlated with a 0.654 standard deviation decrease in the in-class quiz score, relative to students who took the online quiz without a time limit. In other words, taking the online quiz untimed was associated with correctly answering 1.6 more questions on the in-class quiz, compared to students who took the online quiz with a 30 minute time limit.

Results for Principles of Microeconomics are provided in Table 5. For this class, *econliteracy* and *ftstudent* both positively correlate with the performance on *Inclass1* and only *Quizavgplus* is relevant in the regression for *Inclass2*. *Timed1* exhibits a meaningless coefficient in the first regression. In the second regression, *timed2* is positively correlated with *Inclass2*, but the relationship is not statistically significant. Considering both the results from the regressions (Tables 4 and 5) and online quiz scores (Table 3), there is no indication that timing components have any bearing on student learning during the online quiz or the retention of knowledge following the online quiz.

Table 5.
Microeconomics Regressions

Variable	Coefficient	|t|	P > |t|	Coefficient	|t|	P > |t|
Intercept	-2.060	1.52	0.146	-0.208	0.15	0.880
timed1	-0.001	0.00	0.999	-	-	-
quizavg	-0.032	0.75	0.461	-	-	-
quizmissed	-0.022	0.120	0.905	-	-	-
timed2	-	-	-	0.195	0.62	0.540
quizavgplus	-	-	-	0.111	3.79	**0.001**
quizmissedplus	-	-	-	0.060	0.42	0.679
morning	-0.082	0.12	0.824	0.076	0.23	0.822
econliteracy	0.603	0.23	**0.002**	-0.106	0.63	0.535
mathliteracy	0.019	3.53	0.907	0.201	1.04	0.311
age	0.055	0.12	0.238	0.008	0.21	0.836
white	0.382	1.22	0.290	0.036	0.10	0.921
male	0.408	1.09	0.214	-0.523	1.45	0.162
employed	-0.703	1.29	0.116	-0.040	0.09	0.932
ftstudent	1.297	1.65	**0.019**	0.143	0.33	0.748

Conclusions

Utilizing a host of control variables and a collection of data compiled in macroeconomics and microeconomics classes, the authors find that time limits on online quizzes do not seem to influence student learning outcomes. These results conflict with the findings of Brothen and Wambach (2004), who found that timed quizzes lead to more learning than untimed quizzes; a result that convinced some researchers to prefer timed quizzes.[5] The finding presented in the current research is just as reasonable and may result from a more sophisticated statistical analysis, featuring controls for prior knowledge.

If one assumes the finding presented herein is accurate—time limits do not affect learning outcomes—the decision on whether to impose time limits on online quizzes should be based on factors other than student learning outcomes. For example, timed quizzes may cause anxiety (Onwuegbuzie and Seaman 1995). On the other hand, timed quizzes may discourage student cheating (Watters et al. 2011). And certainly, the preferences of students may also play a role in determining the structure and timing of online quizzes. However, it would not be wise to consider the results of the current study as conclusive evidence. For obvious reasons, this analysis utilizes a relatively small sample size. Furthermore, the nature of the subject matter may greatly affect the outcomes in such a study—clearly, a time limit on complex math problems is inherently different from a time limit on memorized content. The results presented should serve to advance the literature on the nature of time limits in e-learning environments, but additional research is needed to determine whether these results are generalizable to students in other economics courses.

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[5] There is also concern that the dearth of published research on time limits may be a result of publication bias. Brothen and Wambach's (2004) result is probably more marketable than inconclusive results that other researchers may have been unable to publish.

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