

Improving student performance in business statistics courses with online assessments

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ABSTRACT

We study the impact of online assessments on student performance in business statistics courses. We quantify the degree to which students take advantage of various online opportunities to improve their quiz grades and estimate its effect on in-class exam scores. We also study the perceptions of students regarding online assessments using anonymous surveys. We find that students believe that multiple attempts at online quizzes help them learn the material, and for the most part take advantage of these opportunities to improve their quiz grades. Furthermore, the effect on exam performance is positive and significant.

Introduction

“I have not failed. I’ve just found 10,000 ways that won’t work.” This is one of Thomas Edison’s most memorable quotations from his account of the trial-and-error process he went through in the development of the incandescent bulb. What a student is able to grasp in the classroom depends on many different instructional, environmental and personal factors (Green, *et al.* 2007 and Rochelle and Dotterweich 2007); however, one potential source of learning could arise from the process of correcting one’s own mistakes. Mistakes may be one of life’s greatest teachers, but the learning one does after making a mistake on a graded assignment is almost always left unmeasured and unrewarded. However, even in the classroom instructors have seen the benefits of coaxing students into revealing deep-seeded and often common misconceptions in order to teach important concepts. In physics, the mistaken belief that heavier objects fall faster than lighter ones can be used to emphasize the importance of clearly understanding the forces of gravity. In any subject area, once a misconception is illuminated, the instructor is then able to go on to point out the source of the common mistake and then develop a more appropriate chain of logic. Similarly, when students struggle with material, an instructor has the option of simply turning over the answer key or allowing the students to expend additional effort and reaching the correct conclusion for themselves. Many instructors choose something closer to the latter method, often because of the notion that students will have a better understanding if they themselves arrive at the correct answer, rather than being presented with it. Though there may be instructional benefits from allowing the student to make mistakes and to struggle with

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finding a correct answer, the process often takes up more time and instructor resources; however, with the movement toward online instruction and with the development of online classroom management software, students can be more easily provided opportunities to make mistakes, and provided incentives to learn from these mistakes, and most importantly allowed to demonstrate that they have learned the material on subsequent exams.

Although online course management software may present the instructor with new challenges in conveying important concepts to a virtual classroom of students, it may also expand the instructor's ability to use quizzes and other outside material as teaching tools (Dutton and Dutton 2005 and Kamuche 2005). In a face-to-face classroom, time constraints often limit in-class quizzes to a single attempt or to a length that is short enough to fit into the classroom schedule. Online classes paired with course management software provide instructors with a reasonably simple way to allow students multiple opportunities to complete assessments, and may allow instructors to have a larger degree of influence over the amount of time spent interacting with the subject matter outside of the classroom. Students are often eager to improve their grades by re-doing assignments, however are less often eager to simply read and study the material beforehand, possibly because the payoff in grades is less immediate. By allowing students to re-do and re-submit quizzes, the instructor may be providing the student with more than just a better grade. Our paper examines the impact of allowing multiple chances on assessment instruments (such as quizzes) on the subsequent exams that focus on the materials in the assessments. This research suggests that, when measured by performance on subsequent exams, allowing multiple attempts on online quizzes increases student learning.

Access to and use of online classroom management systems is becoming the rule rather than the exception in colleges and universities. For the nation as a whole, 66 percent of all higher education institutions offered blended or fully distance education courses in 2006-2007 for a total enrollment of over 12 million. Six years earlier (2000-2001), 56 percent of all institutions offered such courses but enrollment was fewer than 3 million.² The trend towards more online offerings is not limited to fully online courses. Even in traditional classroom settings instructors are relying more and more on online campus classroom management systems such as Blackboard and WebCT, and on publishers' online homework and testing sites such as Aplia, MyEconLab, and Statsportal, among many others.

The findings of the research on the effectiveness of the online environment are mixed. For instance, some authors find that students perform better in face-to-face environments rather than in online courses (see e.g., Brown and Liedholm 2002 and Cybinski and Selvanathan 2005), while others find that student performance is superior among distance learners (e.g., Lynch 2002, Shachar and Neumann 2003, and Cybinski and Selvanathan 2005). There are also several studies that conclude that learning outcomes are the same in both settings (e.g., Johnson 2002, McLaren 2004). This is commonly referred to as the "no significance phenomenon" (Russell 1999). Despite the explosion in online instruction, testing, and research little is known about how effective different testing or quizzing procedures are in online courses, because a large proportion of the current research focuses on all-inclusive measure of performance like GPA.

The evidence from hybrid course environments, those that combine traditional face-to-face and online classroom settings, is also somewhat mixed. Consider, for example, traditional lecture courses that require students to complete homework virtually either online or using computer software. Porter and Riley (1996), Dufresne *et al.* (2002), and Pritchard and Morote (2002) find that virtual homework improves performance, while Bonham *et al.* (2003), Hauk and Segalla (2005), Kassis *et al.* (2008), and Palocsy and Stevens (2008) find that virtual and paper-and-pencil homework assignments have a similar impact on exam performance. While the evidence is not strongly positive, a definite advantage of virtual assessments is that they can be programmed to provide instant quality feedback for students, which should improve learning (Kulik and Kulik 1988). Additionally, it may improve the students' perceived quality of the course.

To a greater or lesser extent, the focus of the literature is on comparing educational outcomes in two different educational settings, traditional classroom versus online, holding as many of the other characteristics of the course as possible constant. Since online classes are fast becoming a fact of life for instructors, a more appropriate question might be, "how might an instructor improve student learning using the advantages afforded by the online environment?"

In this paper we extend the existing literature by looking into the impact of different approaches in online assessments on student performance using data collected from business statistics courses. Since

² National Center for Education Statistics (2002, 2008).

there is evidence that student perception of the course can have an important impact on learning (Ginns and Ellis 2007), we begin by asking students their opinions about the effectiveness of the online assessments. We then build measures that quantify the degree to which students take advantage of multiple online quizzing opportunities to practice using the concepts and to learn the material. Finally, we use the result of these opportunities to measure the impact of online quizzing on in-class exam performance.

What do Students Think about Online Assessments?

A student-opinion survey was administered to students registered in three introductory business statistics courses in the spring semester of 2008. The survey includes questions regarding in-class quizzes, online quizzes that students are only allowed to take once, and online quizzes that students are allowed to take multiple times. Questions deal with the adequacy of each type of quiz as a learning tool and as an assessment tool, and it includes questions about the integrity and fairness of the different types of quizzes.

The survey was available to students registered in the class during the first two week of classes through the campus edition of WebCT Vista. Responses were anonymous and students were encouraged not to identify themselves in any way in the survey.

There were 109 students originally registered in the courses but only 78 completed the survey (71.6% response rate). We summarize students' responses in Tables 1 and 2. These tables summarize the questions included in the survey and the frequency of student responses. The tables reveal that students prefer online to in-class quizzes. Students feel that online quizzing allows them to learn the material but they also claim that they give an unfair advantage to dishonest students. Students do not feel that online quizzes give an unfair advantage to students who miss class regularly or to students who are technologically savvy.

Students were also given the opportunity to write comments on the survey. Students identify the following positive traits of online quizzes:

- they allow students to work at their own pace and time
- they allow students to familiarize themselves with the material
- they allow students to identify problem areas, and
- they allow student to improve their grades

The students also believe that online quizzes:

- allow too much cheating
- tend to be more difficult than in-class quizzes, and
- discourage students from studying hard for the quizzes.

According to students the main advantage of in-class quizzes is that the instructor is present and can address questions immediately.

In addition to the student-opinion survey students were asked to give their feedback on six online quizzes taken during the semester. The quizzes were available on WebCT Vista for approximately one week each. For most of the quizzes students were allowed multiple attempts, with the highest score being recorded as their grade. The instructor encouraged students to email her between attempts if they had questions, and a one-hour time period was agreed upon during which the instructor was available to chat online (using Wimba's Live Classroom ®) with the students. These live chats were meant to incorporate the students' preference for instructor feedback during quizzes within an online environment. During the class period following each quiz deadline students were given a three-question survey. These surveys asked students if the assignments improved their knowledge of the material and their ability to use Excel in statistical analysis, and whether they thought the assignments were a good complement to the regular lecture. Table 3 summarizes the student feelings towards these assignments.

The responses from students summarized in Table 3 were consistently positive. Students report that the online quizzes are helpful learning tools. Students also report feeling that these assignments are a good complement to regular lectures. A definite benefit of online quizzes therefore appears to be the resulting student satisfaction: online quizzes that students can take multiple times make the learning experience more pleasurable.

Table 1: Survey Summary

Question	Agree or strongly agree		Indifferent		Disagree or strongly disagree		No answer	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
1	48	61.54	19	24.36	7	8.97	4	5.13
2	14	17.95	25	32.05	34	43.59	5	6.41
3	24	30.77	32	41.03	16	20.51	6	7.69
4	63	80.77	6	7.69	3	3.85	6	7.69
5	17	21.80	27	34.62	27	34.62	7	8.97
6	20	25.64	24	30.77	24	30.77	10	12.82
7	16	20.51	24	30.77	28	35.90	10	12.82
8	6	7.69	13	16.67	48	61.54	11	14.10
9	13	16.66	17	21.79	38	48.72	10	12.82
10	4	5.13	15	19.23	49	62.82	10	12.82
11	11	14.10	11	14.10	46	58.97	10	12.82
12	10	12.82	7	8.97	51	65.38	10	12.82

Questions:

1. Online quizzes that students can attempt multiple times are a good way to assess what the student has learned (that is, to show the professor how much the student has learned) about the material taught in class or read in the book.
2. Online quizzes that students can only attempt once are a good way to assess what the student has learned (that is, to show the professor how much the student has learned) about the material taught in class or read in the book.
3. In-class quizzes that students can only attempt once are a good way to assess what the student has learned (that is, to show the professor how much the student has learned) about the material taught in class or read in the book.
4. Online quizzes that students can attempt multiple times are a good way to learn or reinforce the material taught in class or read in the book.
5. Online quizzes that students can only attempt once are a good way to learn or reinforce the material taught in class or read in book.
6. In-class quizzes that students can only attempt once are a good way to learn or reinforce the material taught in class or read in the book.
7. Online quizzes that students can attempt multiple times give an unfair advantage to dishonest students
8. Online quizzes that students can only attempt once give an unfair advantage to dishonest students
9. Online quizzes that students can attempt multiple times give an unfair advantage to students who do not attend class regularly.
10. Online quizzes that students can only attempt once give an unfair advantage to students who do not attend class regularly
11. Online quizzes that students can attempt multiple times give an unfair advantage to students who are technologically savvy.
12. Online quizzes that students can only attempt once give an unfair advantage to students who are technologically savvy.

Table 2: Rankings

Rank each of the following according to their effectiveness in assessing how much the student has learned about the material taught in class or read in book.

Responses	Best method	Percent
Online quizzes that students can attempt multiples times	46	60.53
Online quizzes that students can only attempt once	5	6.58
In-class quizzes that students can only attempt once	18	23.68
No answer	7	9.21

Rank each of the following according to their effectiveness in teaching or reinforcing the material taught in class or read in book.

Responses	Best method	Percent
Online quizzes that students can attempt multiples times	48	66.67
Online quizzes that students can only attempt once	3	4.17
In-class quizzes that students can only attempt once	11	15.28
No answer	10	13.89

Table 3: Course Assignments Surveys Summaries

Quiz topic	Improves understanding			Improves understanding of Microsoft Excel and/or distribution tables			Good complement to regular lectures		
	Disagree	Indifferent	Agree	Disagree	Indifferent	Agree	Disagree	Indifferent	Agree
Frequency distributions	7 9.59%	3 4.11%	63 86.31%	20 27.77%	16 22.22%	34 47.23%	6 8.34%	4 5.56%	62 86.11%
Numerical descriptive statistics	7 9.34%	3 4.00%	65 86.67%	10 13.33%	5 6.67%	60 80.00%	5 6.66%	4 5.33%	66 88.00%
Dot plots, percentiles, skewness	2 3.34%	6 10.00%	52 86.66%	15 25.00%	15 25.00%	30 50.00%	1 1.69%	3 5.08%	55 93.22%
Probability concepts	4 7.69%	5 9.62%	43 82.69%	17 32.69%	15 28.85%	20 38.46%	3 5.66%	5 9.43%	45 84.91%
Central Limit Theorem and confidence intervals	4 8.16%	4 8.16%	41 83.67%	3 6.12%	6 12.14%	40 82.17%	4 8.16%	7 14.29%	38 77.55%
Hypothesis tests and confidence intervals	7 12.07%	5 8.62%	46 79.31%	4 6.90%	10 17.24%	44 75.86%	3 5.17%	6 10.34%	49 84.48%

Do Students Take Advantage of Multiple Attempts on Online Quizzes to Improve Quiz Scores?

According to the surveys students seem enthusiastic about the possibilities to learn and improve their scores with online quizzes. Table 4 summarizes the degree to which students actually took advantage of these opportunities.

Table 4: Do students take advantage of multiple tries?

	Quiz # 1	Quiz # 2	Quiz # 3	Quiz # 4	Quiz # 5	Total
Number of students	103	104	97	100	95	499
Number of students who did not score 100 on first try	64	81	79	90	89	403
Number (%) of students who tried more than once	50 (78.12%)	77 (95.06%)	73 (92.41%)	58 (64.44%)	69 (77.53%)	327 (81.14%)
Number (%) of students who tried as many times as possible or until getting a perfect score	45 (70.31%)	59 (72.84%)	73 (92.41%)	58 (64.44%)	69 (77.53%)	304 (60.92%)
Average score in first try (average excluding 100s in first try)	78.90 (66.03)	68.37 (59.38)	79.58 (74.92)	75.40 (72.67)	62.63 (60.11)	72.98 (66.62)
Average highest score (average excluding 100s in first try)	94.56 (91.24)	94.42 (92.84)	93.77 (92.35)	80.85 (79.72)	74.00 (72.25)	87.72 (85.68)
Number of tries allowed	Unlimited	Unlimited	2	2	2	

Approximately 81% of students who did not score a perfect 100 on their first quiz attempt tried a second time, and about 61% tried until they either got a perfect score or until they ran out of attempts. On average, students improved their quiz scores almost 20 points from a D (66.62) to a B (85.68). While multiple attempts clearly allow students to improve their quiz scores, the most interesting question is: do they improve in-class exam performance?

Does Taking Quizzes Multiple Times Improve Student Performance?

In this section we use in-class exam grades to calculate the effects of online assessments on student performance. The basic question that we are trying to answer is: do students who take advantage of the opportunities to improve their quiz scores by retaking quizzes perform better than students who do not take advantage of these opportunities?

There were three regular exams during the semester and two online quizzes before each exam. We use the data from the three exams (*TESTS*) to measure student performance. The unit of observation is the exam; thus, each student therefore denotes three observations in our study.

We measure the degree to which students take advantage of the various online opportunities by calculating four different variables or indices. These indices are based on the quizzes taken before exams. The first index is simply called “*DUMMY INDEX I*” and it can take on only two values. If a student scores a perfect 100 on the first attempt he/she is excluded from the sample. If he/she scores less than 100 percent on one or both quizzes but attempts at least once to improve his/her score the index equals 1. If he/she never tries a second time the index equals zero. This index captures students who either habitually or occasionally take advantage of the opportunity to improve their quiz scores.

We build a second index, “*DUMMY INDEX II*”, which equals 1 for students who always try to improve their quiz scores, and zero otherwise. This second index identifies students who consistently try to improve their scores while it excludes the occasional student.

For our third index we count the number of times students attempt quizzes. We call this our “*CATEGORICAL INDEX*”. This index includes all students, even those who score a perfect 100% on the first attempt.

Our final measure, “*AVERAGE POINTS WON*”, captures how much students improve their quiz scores. For each quiz we calculate the difference between the highest and the first quiz scores. We then average the points gained in the two quizzes preceding each test.

All else equal, we expect students who improve their quiz scores through multiple attempts will perform better on in-class exams. More specifically, if we compare two students who are alike in every observed way except in the degree to which they take advantage of the opportunities to improve their quiz grades we expect the student with a higher index measure to perform better on tests.

To test our hypothesis we run a linear regression model in which the variable *TESTS* is the dependent variable and one of our *INDEX* measures is the independent variable. To control for possible innate aptitudes we include the student *GPA* as a regressor. Furthermore, we include the number of hours the student is enrolled in (*ENROLLED HOURS*) to account for time constraints, the student age (*AGE*) to account for maturity level, and the student gender (*FEMALE*). We also include the variable *QUIZ* on the right hand side. *QUIZ* denotes the average score earned in the first attempts at the quizzes. We include this variable because the number of times a student attempts a quiz and the number of points earned are likely a function of his/her first attempt score. For example, a student who scores a 100 on his/her first attempt does not need to try again and will gain zero points. The four models we estimate can be summarized in the following equations:

$$TESTS=c_{10}+c_{11}GPA+c_{12}FEMALE+c_{13}AGE+c_{14}ENROLLED\ HOURS+c_{15}DUMMY\ INDEX\ I+c_{16}QUIZ$$

$$TESTS=c_{20}+c_{21}GPA+c_{22}FEMALE+c_{23}AGE+c_{24}ENROLLED\ HOURS+c_{25}DUMMY\ INDEX\ II+c_{26}QUIZ$$

$$TESTS=c_{30}+c_{31}GPA+c_{32}FEMALE+c_{33}AGE+c_{34}ENROLLED\ HOURS+c_{35}CATEGORICAL\ INDEX+c_{36}QUIZ$$

$$TESTS=c_{40}+c_{41}GPA+c_{42}FEMALE+c_{43}AGE+c_{44}ENROLLED\ HOURS+c_{45}AVERAGE\ POINTS\ WON+c_{46}QUIZ$$

Variable definitions and descriptive statistics are presented in Table 5, and the results from the regressions are summarized in Table 6.³ All models show that *GPA* and *QUIZ* both have a positive and significant impact on exam performance, as expected, while *AGE*, *FEMALE* and *ENROLLED HOURS* are not significant. The fact that student gender does not have a significant effect on exam performance is in itself an interesting result. Traditionally, female students outperform their male counterparts in high school and college. This is reflected in a slightly higher average *GPA* among females in our sample (2.98 vs. 2.78 in males). Our results, however, suggest that, despite the higher *GPA*, females do not outperform males on exams in business statistics courses. Point estimates indicate the contrary but are not statistically significant at the 10 percent level. A plausible explanation is that male students are closing the gap by taking quizzes over and over again.

All the models show that there is a positive and significant relationship between online activity and exam performance. Model 1 shows that students who attempt the quizzes more than once, even occasionally, can improve their exam scores by an average of 8.14 points. In other words, those students who try (even occasionally) to improve their quiz scores by taking advantage of the opportunity to take quizzes multiple times earn, on average, 8.14 points more (out of 100) on exams than students who never retake quizzes. For example, consider a student who has a 2.0 *GPA* and scores a 50% on average on the quizzes. If this student does not attempt quizzes again, he or she can be expected to earn a D on the test. More specifically, model 1 predicts a score of 64.26.⁴ Now consider another student who also has a 2.0

³ The variables *FEMALE*, *AGE*, *GPA*, and *ENROLLED HOURS* were obtained from university records. All other data come from instructor records.

⁴ To calculate 64.26, we substitute the *GPA* and *QUIZ* values on the equation estimated by model 1: $36.66 + 10.55(2.0) + 0.13(50) + 8.14(0) = 64.26$.

GPA and scores a 50% average on the quizzes. This student however tries to improve his/her quiz scores by taking the quizzes again (at least once). Model 1 predicts that he/she will earn a 72.40 or a C on the exam.⁵

Table 5: Descriptive statistics

	DEFINITION							
<i>TESTS</i>	Student score on in-class exams.							
<i>FEMALE</i>	Dummy variable = 1 if student is female and 0 otherwise.							
<i>GPA</i>	Student GPA.							
<i>AGE</i>	Student age.							
<i>ENROLLED HOURS</i>	Number of hours the student is currently enrolled in.							
<i>DUMMY INDEX I</i>	Dummy variable = 1 if student tried at least once to improve quiz scores and 0 otherwise.							
<i>DUMMY INDEX II</i>	Dummy variable = 1 if student tried every time to improve quiz scores and 0 otherwise.							
<i>CATEGORICAL INDEX</i>	Categorical variable = number of times student tried quizzes before tests.							
<i>AVERAGE POINTS WON</i>	Average of the difference between the highest and first quiz scores for the two quizzes preceding each							
<i>QUIZ</i>	Average score on the two quizzes preceding each test.							
	Mean	Median	Max.	Min.	Std. Dev.	Sum	Obs.	
<i>TESTS</i>	78.77	80.00	110.00	40.00	14.39	24811.41	3	
<i>FEMALE</i>	0.35	0.00	1.00	0.00	0.48	111.00	3	
<i>GPA</i>	2.85	2.81	4.00	1.97	0.49	906.69	3	
<i>AGE</i>	22.52	21.00	44.00	19.00	3.95	7161.00	3	
<i>ENROLLED HOURS</i>	13.58	14.00	23.00	3.00	2.96	4317.00	3	
<i>DUMMY INDEX I</i>	0.83	1.00	1.00	0.00	0.37	235.00	2	
<i>DUMMY INDEX II</i>	0.73	1.00	1.00	0.00	0.45	205.00	2	
<i>CATEGORICAL INDEX</i>	3.60	3.00	20.00	1.00	2.38	1110.00	3	
<i>AVERAGE POINTS WON</i>	15.02	10.00	98.65	0.00	17.91	4627.59	3	
<i>QUIZ</i>	71.83	75.00	5.00	100.00	20.73	22124.00	3	

Similarly to model 1, model 2 shows that students who try consistently to improve their quiz scores can increase their exam grades. The coefficient of 3.44 indicates that students who always try to improve their scores by retaking their quizzes score on average 3.44 higher (out of 100) on the exams than other students.

Models 3 and 4 quantify the impact of taking quizzes multiple times in a more continuous approach. Instead of looking at the dichotomous choice (whether or not students take advantage of multiple tries), model 3 looks at the impact of the exact number of tries as a categorical variable, and model 4 looks at the impact of the total points earned by trying quizzes multiple times. Model 3 shows that after controlling for student ability and preparation (*GPA*), the score on the first attempt (*QUIZ*) and other variables, the more times a student tries a quiz, the higher his/her exam score will be. All else equal, for each extra quiz attempt exam scores go up by 1.45 points. For example, consider three students who all have a 2.0 *GPA* and all score a 70 on their first quiz attempts. The student who never tries a second time to improve his/her quiz score can be expected to earn a 69.32 (=33.99 + 11.34 (2.0) + 0.16 (70) + 1.45 (1)) on the exam; a student who tries twice can be expected to earn a 70.77 (=33.99 + 11.34 (2.0) + 0.16 (70) + 1.45 (2)); the last student tries the quiz three times. He/she can be expected to score 72.22 (=33.99 + 11.34 (2.0) + 0.16 (70) + 1.45 (3)). Finally, according to model 4, for every point gained by retaking the quizzes exam scores increase by 0.21 points.

⁵ We come up with 72.40 by doing the following calculation: 36.66 + 10.55 (2.0) + 0.13 (50) + 8.14(1) = 72.40.

Table 6: Performance estimations

	Model 1		Model 2		Model 3		Model 4	
	Coef.	P-val	Coef.	P-val	Coef.	P-val	Coef.	P-val
<i>CONSTANT</i>	36.66	0.00	39.02	0.00	33.99	0.00	32.24	0.00
<i>GPA</i>	10.55	0.00	10.44	0.00	11.34	0.00	10.73	0.00
<i>FEMALE</i>	-2.35	0.14	-2.38	0.14	-1.24	0.42	-1.28	0.41
<i>AGE</i>	0.05	0.81	0.10	0.67	-0.04	0.87	0.01	0.94
<i>ENROLLED HOURS</i>	-0.30	0.34	-0.21	0.52	-0.21	0.48	-0.16	0.59
<i>QUIZ</i>	0.13	0.00	0.13	0.00	0.16	0.00	0.21	0.00
<i>DUMMY INDEX I</i>	8.14	0.00						
<i>DUMMY INDEX II</i>			3.44	0.04				
<i>CATEGORICAL INDEX</i>					1.45	0.00		
<i>AVERAGE POINTS WON</i>							0.21	0.00
Observations	281.00		281.00		307.00		307.00	
R ²	0.25		0.21		0.27		0.27	

It is important to note that since students who score higher on the first quiz attempt have less to gain from re-taking quizzes multiple times, the two indices, *CATEGORICAL INDEX* and *AVERAGE POINTS WON*, result in negative correlations with the *QUIZ* scores. In fact, the correlation between *CATEGORICAL INDEX* and *QUIZ* is -0.25 (p-value = 0.00) and the correlation between *AVERAGE POINTS WON* and *QUIZ* is -0.48 (p-value=0.00). This needs to be taken into consideration when results are interpreted, since the potential co-linearity between the two regressors could dampen their t statistics. That is, variables that are, in fact, statistically significant might appear not to be (low t-statistics, high p-values), because they both measure the same variation in the dependent variable; however, in our models all indices and the *QUIZ* variables are highly significant. Moreover, the estimates of test performance remain robust to the different measures of quiz activity and performance. Regardless of the measure used, our results are consistent in sign and significance. Students can improve in-class exams by taking quizzes online multiple times. Furthermore, students who are weaker to begin with can benefit the most from multiple attempts.

Conclusions

In this paper we present the perceptions of students regarding online assessments, and study the degree to which they take advantage of the opportunities to improve quiz scores by taking quizzes multiple times, and we further estimate the impact this has on in-class exam performance. We find the following:

- (1) Students find online quizzes convenient.
- (2) Students feel that the ability to improve their quiz scores by being allowed several attempts helps them learn the material.
- (3) Most students take advantage of the opportunity to increase their quiz scores by attempting them multiple times.
- (4) Regression analysis shows that students actually score higher on tests when they take quizzes multiple times.

There are, however, drawbacks to quizzing students online. Three common concerns raised by students are:

- (1) They like to have the instructor available to ask questions during quizzes.
- (2) They perceive that online quizzes may encourage cheating.
- (3) They think that online quizzes that students can take multiple times discourage studying for quizzes.

Although these are legitimate concerns, they are not insurmountable. Technology today is such that email, text messaging, and video chats, to mention a few options, allow the instructor to be available to students, if not physically, then virtually.

Cheating can be reduced (although perhaps not completely eliminated). Most classroom management systems allow instructors to design tests that change the questions on each attempt. Cheating can also be reduced by limiting the time the quizzes are available, by protecting access to quizzes with passwords, or by limiting other computer activity while the student is taking the quiz.

Finally, there are grading schemes that may be used to encourage students to study ahead of time for quizzes. For example, instead of assigning the highest score from the multiple attempts on the quiz as the final quiz grade, instructors can assign the average of all scores. This would reduce the incentive for students simply guessing and re-guessing since each attempt would have an effect on the average quiz grade.

Even though our results show that taking quizzes online multiple times increases student performance on the subsequent exams covering the same material, our study does not fully explore the reasons why this is so. That is, there is a learning mechanism that we need to understand better. One logical next step of this line of research is to dissect the possible components of this mechanism and study their individual effects on exam performance. For example, does varying the way credit is awarded for subsequent quiz attempts (i.e., changing the risks associated with the final quiz grade) affect the decision to re-take the quiz or to study more before taking it the first time?

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