Research in Economic Education

In this section, the *Journal of Economic Education* publishes original theoretical and empirical studies of economic education dealing with the analysis and evaluation of teaching methods, learning, attitudes and interests, materials, or processes.

PETER KENNEDY, Section Editor

Are Online Exams an Invitation to Cheat?

Oskar R. Harmon and James Lambrinos

Abstract: In this study, the authors use data from two online courses in principles of economics to estimate a model that predicts exam scores from independent variables of student characteristics. In one course, the final exam was proctored, and in the other course, the final exam was not proctored. In both courses, the first three exams were unproctored. If no cheating took place, the authors expected the prediction model to have the same explanatory power for all exams, and, conversely, if cheating occurred in the unproctored exam, the explanatory power would be lower. Their findings are that both across and within class, variations in the *R*-squared statistic suggest that cheating was taking place when the exams were not proctored.

Keywords: assessment, cheating, face-to-face, online, undergraduate economics
JEL codes: A2, A22

Online offerings of economics classes have experienced a recent growth surge. In the fall of 1997, Sosin (1997) surveyed 986 economics departments at post-secondary institutions and received 325 completed surveys for a response rate of 33 percent. Of the respondents, only 24 institutions offered a total of 40 online courses. Coates and Humphreys (2001) conducted a similar survey three years later of approximately 750 higher education institutions and received approximately 260

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completed surveys for a response rate of 35 percent. Of the respondents, 120 institutions offered 189 economics courses online. A comparison of the two surveys shows that in the 3-year interval, the number of institutions offering online economics courses increased by 400 percent and the number of these courses increased by 373 percent.

Among college educators, there is a widespread belief that the extent of academic misconduct is on the rise (Hard, Conway, and Moran 2006). The issue is central to online instruction because in the absence of the ID confirmation afforded by a proctored exam, it is impossible to know whether the registered student or a substitute has taken the assessment or if students worked collaboratively on the exam. We report the findings of a natural experiment wherein an identical exam was administered in a proctored and an unproctored setting, holding constant factors such as instructor, text, and delivery method. Our purpose is to contribute useful information to instructors as they decide whether to administer proctored or unproctored assessments in their online courses.

LITERATURE REVIEW

There is an emerging literature on the appropriate design for assessment in online instruction. One view is that a proctored test is the best practice for online assessment (Edling 2000; Rovai 2001; Deal 2002). These authors take the position that "Proctored testing is particularly relevant when testing is for high-stakes, summative purposes" because of the ease of cheating in an unproctored environment (Rovai 2001, 144). Even for students geographically distant from the offering, campus proctored tests are feasible because there are numerous commercial testing centers and alternative not-for-profit testing collaborations (Liefert 2000; Young 2001; Taylor 2002). The alternative view is that with appropriate adjustments in format (e.g., randomized questions from a large pool of test questions, open-book testing with time constraints so students do not have time to look up answers, etc.) the probability of cheating in the proctored and unproctored format can be brought to equivalent levels (Vachris 1999; Shuey 2002; Serwatka 2003).

The literature on the extent and determinants of cheating on college campuses is quite extensive (Passow et al. 2006).[1] These studies examined cheating behaviors in general; they did not examine whether cheating behaviors were different in online instruction compared to face-to-face instruction. Two earlier studies in this journal focused on the determinants of cheating in face-to-face principles of economics classes. In one study, Kerkvliet and Sigmund (1999) used random-response survey data to measure the effectiveness of measures to reduce cheating. A random-response survey asked the respondent to anonymously self-report cheating behavior. The study findings were that the most effective deterrent was using tenure-track faculty instead of graduate teaching assistants as proctors (32 percent reduction in the probability of cheating), followed by using an additional test version (25 percent reduction), and simple use of verbal announcements (12 percent reduction). In another study, Nowell and Laufer (1997) used direct evidence of cheating to examine student characteristics as predictors of cheating. In their experiment, students were administered a quiz, which was collected, photocopied, and

returned to the student to self-grade. The self-graded score was compared to the score calculated from the photocopy, and discrepancies were direct evidence of cheating. The authors reported that the likelihood of cheating was positively associated with the student characteristics of poor performance in class and increased hours of employment.

There are only a few empirical studies of cheating in online classes (Charlesworth, Charlesworth, and Vlcia 2006). Two studies were of student perceptions of cheating in online courses, and one (Kennedy, Nowak, and Raghuraman 2000) reported findings consistent with the view that cheating is more likely to occur in the online class than in the traditional face-to-face class. The other study (Charlesworth, Charlesworth, and Vlica 2006) reported that cheating is no more likely to occur in the online class than in the face-to-face class. A third study (Grijalva, Nowell, and Kerkvliet 2006), using an anonymous survey of self-reported cheating for students in online courses, reported that the incidence of cheating was similar to that reported for similar studies of cheating in face-to-face courses.

There are, to our knowledge, no published studies of cheating in online courses in economics. Understanding of the potential dimension of the problem of online cheating is further limited because there are no studies, to our knowledge, of the extent to which unproctored assessments are used in online principles of economics courses. We reviewed four studies in the expanding literature that compares the effectiveness of online instruction and face-to-face instruction in principles of economics. These reported using the unproctored format (Vachris 1999; Navarro 2000; Coates et al. 2004; Anstine and Mark 2005) for assessments in their online classes. Because of the relatively higher cost of the proctored format (Young 2001), the former group may represent the tip of the iceberg regarding the common practice for assessment in online principles of economics classes.

Our purpose in this study was to begin to fill the gap of empirical research in the literature on the extent and determinants of online cheating in principles of economics classes. We used data from two online courses in principles of economics to estimate a model that predicts exam scores from independent variables of student characteristics. In one course, the final exam was proctored, and in the other course, the final exam was not proctored. In both courses, the first three exams were unproctored. If no cheating occurs, we expected the prediction model would have the same explanatory power in both classes, and, conversely, if cheating occurs, there would be a lower explanatory power in the class with the unproctored exam. We expected that if cheating occurs, the R-squared statistic would be relatively low because a large portion of the variation would be explained by cheating, which is an omitted variable in the model. To our knowledge, this is the first empirical study of cheating on unproctored assessments in online economics classes, and it is the first study to use the R-squared statistic to detect whether cheating has occurred.[2]

DATA

In our study, we used data from two courses, an online class in principles of macroeconomics taught in summer 2004 and the same class taught in summer 2005.

Both classes were for the Online Division of the School of Continuing Studies at the University of Connecticut. In summer 2004, the enrollment was 25 students, and we had information for 24 of these students. In summer 2005, the enrollment was 40 students, and we had information for 38 of these students. The courses, although offered a year apart, were almost identical in structure and content. The required readings consisted of chapters in a standard principles of macroeconomics textbook. The online instructional materials included PowerPoint presentations augmented with audio sound files, online practice problems in Excel spreadsheets, and readings from the online edition of the *Wall Street Journal* as background for participation in twice weekly instructor-moderated online discussions.

Each course was offered entirely online, using the course management software WebCT.[3] Each course had three, 1-hour-long exams weighted as 18 percent of the course grade (a total of 54 percent), required participation in a discussion bulletin board for each chapter weighted as 18 percent, and a cumulative 90-min final exam weighted as 28 percent. The corresponding exams for each course were identical. Each of the three exams, had 20 multiple-choice questions (the final exam had 30), each exam was randomly selected from a pool of approximately 100 multiple-choice questions, and the response choices were randomly ordered.[4] No student taking the course in 2004 took it again in 2005.

The sole significant difference between the two courses was that, in summer 2004, the final exam was unproctored, and in summer 2005, the final exam was proctored. Students did not know prior to enrollment whether the exams would be proctored, so self-selection bias was unlikely.[5] In the summer 2004 course, all four exams were unproctored. Students had a 3-day period, usually encompassing a weekend, in which to take the exam. After log-in, the student had 60 minutes to complete the exam (90 minutes for the final exam). The exams could be taken anywhere the student could have access to the Internet. In the summer 2005 class, the three 60-minute exams were administered as in the summer 2004 class. The final exam, however, was required to be taken at one of five university campus locations, or at a preapproved testing site.

The procedures for proctoring the summer 2005 final exam followed the guidelines recommended by Kerkvliet and Sigmund (1999) that proctors should not be teaching assistants, multiple versions should be used, and verbal warnings should be given. At the university campus locations, the test was proctored by a faculty member or an administrator in the Division of Continuing Studies. Five students took the test off-campus and were proctored by the testing center staff, clergy, or faculty at other universities and colleges. The proctors were given identical guidelines. Students were required to present a valid photo ID to sit for the exam. The exam was administered for a 90-minute period, beginning at exactly the same time at all testing locations. Notes, books, scratch paper, computer files, and calculators were allowed. Printing or copying the exam or parts of the exam was not permitted. Cell-phone usage and other forms of communication, such as instant messaging, were not allowed. Proctors gave a verbal warning about academic dishonesty.

The data for our study consisted of scores on the four exams in the course and, from university records, the student's cumulative grade point average (GPA) at the beginning of the semester, age, academic major, and college grade level.

TABLE 1. Descriptive Statistics

Variable	Summer 2004 Mean	Summer 2004 *SD*	Summer 2004 Number of observations	Summer 2005 Mean	Summer 2005 *SD*	Summer 2005 Number of observations	*t* test of difference between 2004 and 2005 means
EXAM1	65.41	17.99	24	70.40	15.62	38	−1.16
EXAM2	84.79	11.75	24	84.57	13.15	37	0.07
EXAM3	68.75	12.18	24	78.09	12.55	38	−2.89**
FINAL EXAM	73.23	13.01	24	77.15	10.33	38	−1.32
GPA	2.86	0.55	24	3.00	0.54	38	−0.99
SOPHOMORE = 1	0.58	0.50	24	0.71	0.46	38	−1.05
JUNIOR = 1	0.21	0.41	24	0.12	0.33	38	1.33
SENIOR = 1	0.04	0.20	24	0.18	0.39	38	−1.63
ECON_MAJOR = 1	0.29	0.46	24	0.21	0.41	37	0.71
AGE	20.70	4.29	22	20.50	3.03	37	0.31

*significant at the .10 Type 1 error level.
**significant at the .05 Type 1 error level.

Descriptive statistics for the students' characteristics are shown in Table 1. A test of the difference between the means of the variables for each course is reported in column 4 of Table 1. The average exam score for the summer 2004 course was generally below that for the summer 2005 course. These differences were statistically significant only for the third hourly exam. The average GPA was slightly lower in the summer 2004 course compared to the summer 2005 course (2.86 compared to 3.00), but the difference was not statistically significant. The distribution by class standing was similar between the courses. The slight differences in the means of the indicator variables SOPHOMORE, JUNIOR, and SENIOR were not statistically significant. The percentage of economics majors was larger in the summer 2004 class (29 percent) than in the summer 2005 class (21 percent), but the difference was not statistically significant. On balance, the two sections had approximately the same average level of human capital endowments.

Method and Results

The model for prediction of exam score was determined by past research studies (Anderson, Benjamin, and Fuss 1994; Brown and Liedholm 2002; Coates et al. 2004; Dickie 2006; Marburger 2006; Stanca 2006) and by data availability. The model was

$$\text{EXAM}(i) = b_0 + b_1\text{GPA} + b_2\ \text{SOPHOMORE} + b_3\ \text{JUNIOR} + b_4\ \text{SENIOR} + b_5\ \text{ECON\_MAJOR} + b_6\ \text{AGE} + U_j.$$

The variables used in the study and their definitions are shown in Table 2. The dependent variable EXAM(i) was the test score for the four exams so that $i = 1 - 4$. GPA was the student's grade point average at the beginning of the

TABLE 2. Definitions of Variables

Variable	Definition
AGE	Age in years
SOPHOMORE	1 if sophomore, 0 otherwise
JUNIOR	1 if junior, 0 otherwise
SENIOR	1 if senior, 0 otherwise
ECON_MAJOR	1 if an economics or business major, 0 otherwise
EXAM1	Score on exam 1
EXAM2	Score on exam 2
EXAM3	Score on exam 3
EXAM4	Score on final exam
GPA	Cumulative GPA at begining of semester
PROCTOR	1 if exam proctored, 0 otherwise

semester; it was used as a measure of student ability,[6] and its expected effect was positive (Anderson, Benjamin, and Fuss 1994; Dickie 2006; Stanca 2006). SOPHOMORE, JUNIOR, and SENIOR were indicator variables equal to one if the student had the same class rank as the variable name and 0 otherwise. These indicator variables were taken as a measure of student maturity and experience with academics and were expected to have positive signs. ECON_MAJOR was an indicator variable equal to one if the student was an economics or business major, and 0 otherwise. It was expected to have a positive sign as majors in the discipline of the course were expected to have greater motivation to perform well. The sign for AGE was not hypothesized. A small portion of the students were returning adult learners enrolled in the Division of Continuing Studies and had distinctly different circumstances than the majority of the students. These older students tended to exercise greater responsibility toward academic achievement, implying a positive sign, but they faced greater opportunity costs arising from greater family and job responsibilities, implying a negative sign.

To detect cheating, we compared the R-squared statistic of the summer 2004 results to the R-squared statistic of the summer 2005 results. The rationale for using the R-squared statistic to detect cheating was as follows: We assumed that the more human capital variables worked to explain test scores, the more the likelihood that the test scores reflected the student's own ability. If human capital variables, such as GPA and whether the student was an economics major, explained a high percentage of the variation in test score, it was more than likely their own effort that caused this high correlation between ability and test scores. Cheating should serve to weaken this correlation, resulting in a low R-squared statistic. If the proctored final exam was associated with an unusually high R-squared statistic, it would be difficult to conclude that this was not related to an absence of cheating during this exam.

The results of the eight OLS regressions (one for each of four exams in the two courses) are reported in Table 3. Because GPA was the only substantive explanatory variable, and an F test indicated that the other explanatory variables

TABLE 3. Determinants of Final Exam Score (Parameter Estimates)

	Summer 2004				Summer 2005			
Variable	Exam 1	Exam 2	Exam 3	Final exam	Exam 1	Exam 2	Exam 3	Final exam
INTERCEPT	40.37**	63.90***	65.98***	71.28***	43.82***	66.32***	46.79***	41.08***
	(19.41)	(12.35)	(13.63)	(14.58)	(12.49)	(11.16)	(9.05)	(6.14)
GPA	8.76	7.38*	0.97	0.68	9.28**	5.92	10.42***	12.09***
	(6.67)	(4.25)	(4.69)	(5.01)	(4.13)	(3.66)	(2.99)	(2.03)
R square	0.0306	0.0786	0.0019	0.0008	0.1232	0.0695	0.2524	0.4972
F ratio	1.73	2.96*	0.04	0.02	5.06**	2.61	12.15***	35.60***
N	24	24	24	24	38	38	38	38

Note. Standard errors are in parentheses below the parameter estimate.
*significant at the .10 Type 1 error level.
**significant at the .05 Type 1 error level.
***significant at the .01 Type 1 error level.

(SOPHOMORE, JUNIOR, SENIOR, ECON_MAJOR, and AGE) were statistically insignificant as a group, we report in Table 3 the results for the simplest specification. For the summer 2005 course, the *R* squared for the proctored final was 49.7 percent, much higher than the *R* squared for the first three unproctored exams, which averaged 15 percent. For the summer 2004 course, the *R* squared for the unproctored final was only 0.08 percent, 49.6 percent percentage points below that for the proctored final in the summer 2005 course.

The Goldfeld-Quandt test, commonly used to test for heteroskedasticity, could be used as a test for equality of error variance across the two classes. The calculated *F*-ratio statistic for testing the equality of the error variance between the unproctored and proctored final exam models was 3.41, and the *p* value was less than 0.01. This suggested that the error variances were significantly different between the two classes.

Another approach to detect if cheating was taking place is to use the equation for the proctored final exam to predict the final exam score for the unproctored class. If the class had many students whose predicted final exam score was far from their actual score, that was taken as an indication that cheating may have taken place. The standard error of the prediction interval was roughly 8 points, so two standard errors would be roughly 16 points. Adjusting for the difference in final exam scores, we found 8 students whose actual score was more than 16 points from the predicted score. Of these, 3 (13 percent) had scores that were worse than expected, and 5 (21 percent) had scores that were better than expected.[7]

CONCLUSIONS

In this study, we addressed this question: Does mode of assessment format (proctored or unproctored exams) affect test scores in online principles of economics classes? The data for the study were from two courses of principles of macroeconomics, one taught in summer 2004, the other in summer 2005. The courses were identical in every respect, except that the final exam in the summer 2004 course was not proctored, and the final exam in the summer 2005 course was proctored. To detect cheating, we estimated a model for each class that predicted exam scores from independent variables of student characteristics and compared the *R*-squared statistic for each exam. We expected that if no cheating took place the prediction model would have the same explanatory power for all exams, and, conversely, if cheating occurred in the exams that were unproctored, the explanatory power would be lower. We concluded that cheating took place because the comparison of the *R*-squared statistics revealed that the human capital variables did not explain nearly as much of the variation in test scores in the unproctored format as they did in the proctored format. The potential for a higher incidence of academic dishonesty in online courses than in face-to-face courses has been much discussed, and many authors have commented on the dearth of empirical evidence. Although our data are limited to two undergraduate classes in principles of economics at a single institution, our results suggest that online exams administered in a proctored environment might equalize the incidence of academic dishonesty between online courses and face-to-face courses.

NOTES

1. The studies consistently reported that the highest incidence of cheating occurs among vocational majors such as business and engineering (Passow et al. 2006).
2. Passow et al. (2006) used a similar method. They estimated parallel models for exam cheating and homework cheating. They concluded that the dramatic difference in the *R*-squared statistics is evidence that the factors that determine the frequency of exam cheating and homework cheating are different.
3. Except for the proctored exam for the summer 2005 class, there were no other face-to-face meetings for either class.
4. The exams were structured so that each student had a different exam, but the exams were of equivalent difficulty. For example, on a question to calculate marginal propensity to consume, there were 5 alternative versions of the question, each version differing by the specific numbers given in the question. All 20 questions, including nonnumerical question types, were designed in this manner. When a student logged on, the WebCT software created the exam by random selection of 20 questions, each from a pool of 5, and randomly selected the order of responses for each question.
5. The course was first offered online in summer 2004. The course description released at the time of enrollment in February 2004 for summer school did not contain information as to whether exams would be proctored. The course description for the summer 2005 was the same as previously. The decision to administer the final exam in proctored format was made in late April and announced to students during the first week of class in mid-May 2005. This resulted in considerable inconvenience for some students, and, in the following year, the information was incorporated in the course description released during the enrollment period. Because students did not know beforehand whether the final exam in summer 2005 would be proctored, we believe that self-selection by reason of assessment format was not an issue with our data.
6. A recent study of explanatory variables in research on student learning concluded that collegiate GPA is the best proxy for individual student aptitude for academic learning (Grove, Wasserman, and Grodner 2006).
7. We undertook one other approach to identifying outcomes that possibly reflect cheating behaviors. Because the *R* square is much lower for the unproctored students for the third and fourth exams than for the first and second exams, it can be speculated as resulting from those students in trouble after the first two exams deciding to cheat on the remaining two exams. We calculated a class rank on the basis of the average of the first two exams and compared that to the rank for the average of the last two exams. We identified three students (13 percent) as having a marked increase in class rank after the second exam, so large that they were outliers to the other students in the sample. Of this group, one had a low GPA (2.09) and also had a large and positive difference between the actual final exam score and the predicted final exam score.

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