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An Analysis of Online Examinations in College Courses

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This research evaluates the use of online examinations in college courses from both instructor and student perspectives. Instructional software was developed at Kansas State University to administer online homework assignments and examinations. Survey data were collected from two classes to measure and evaluate the level of student preferences for online examinations. The statistical determinants of student preferences for online testing were identified and quantified using logistic regression analysis. Strategies for the effective use of online examinations are summarized for potential adopters of online examinations.

Key Words: online examinations, student learning, teaching technology, undergraduate teaching

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The use of information technology in college-level instruction has become nearly ubiquitous (Barkley 2001; Gilbert; Green; Green and Gilbert; Newman, Ram, and Day; O'Kane and Armstrong). Classroom technologies such as presentation software, course websites, and online homework assignments have been rapidly implemented as computer technology has advanced (Barkley 2000; Barkley and Haycock). However, online testing, or examinations administered via the internet, has yet to be utilized extensively. The adoption and use of online examinations could help college and university instructors meet several pedagogical and instructional objectives, including (1) frequent assessment of student learning, (2) elimination of grading requirements and costs, (3) immediate feedback to students, and (4) elimination of paper and copying costs (Pyle). The relatively low interest level and slow adoption of online testing may be due to (1) software requirements, (2) hardware requirements, (3) issues associated with cheating and/or dishonesty, (4) a preference by teachers of agricultural economics for teaching styles and tools that emphasize social interactions and "hands-on" approaches, and (5) logistical constraints, including space and time requirements. Space requirements may involve the use of an existing computer laboratory or development of a new laboratory. Successful implementation of online examinations requires the devotion of faculty, staff, and administrative time and energy to logistical and institutional change. Because both space and time are scarce resources in colleges and universities, these constraints can be binding, slowing the adoption of online exams.

The objective of this research is to evaluate and assess the use of online examinations in college courses from the perspective of both the instructor and the students. Instructional

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software has been developed and used at Kansas State University to administer both homework assignments (Barkley and Haycock) and examinations over the internet. Students can complete homework assignments at any time by submitting answers to multiple-choice questions from any location that has internet connectivity. Examinations can be securely administered by limiting access to the internet to computers in a specific location, such as a computer lab, by restricting access to the web page to only those IP addresses for the computers in the testing laboratory.

This article will provide an evaluation of online testing from the instructor's point of view by describing and discussing the benefits and costs associated with online testing. Next, student opinions are evaluated with the use of survey data collected from two large Principles of Agricultural Economics and Agribusiness courses (AGEC 120) at Kansas State University during Spring 2000 and 2001 (301 observations). These data were used to measure the level of student satisfaction with and approval of the use of online examinations. The determinants of student preferences for online assignments and testing were identified and quantified using logistic regression analysis. The development, adoption, and implementation of online examinations are summarized and evaluated for teachers and administrators interested in the future use of this instructional tool.

Background and Motivation for Online Testing

The primary motivation for the development and implementation of online examinations in a large course was the elimination of the high costs of grading assignments and exams in a large class. Large courses force instructors to carefully consider how assignments and examinations will be administered because grading can be time-consuming (when instructors grade) or expensive (when teaching assistants grade). For this reason, the use of multiple-choice questions is pervasive in college courses with large enrollments but may be inferior to essay questions that require critical thinking, evaluation, or assessment from a pedagogical point of view (Borcher, Pinckney, and Clemens; Bracey; Haney and Madaus). Numerous tradeoffs are involved in exam format selection. For example, multiple-choice exams are less costly and time consuming to grade than essay tests. However, effective multiple-choice questions are typically more time-consuming to write and evaluate as testing instruments than essay questions.

Many instructors use electronic scanning devices to grade multiple-choice examinations (Suen and Parkes). The use of online examinations can extend and enhance scanner technology by having students select answers to multiple-choice questions on a computer connected to an internet site. The computer automatically and instantly grades examinations and, after the exam has been taken by all students, a score is reported to both an exportable instructor grade book (spreadsheet) and to the individual student via a secure personal spreadsheet available only to each student. Online examinations are also likely to provide benefits to teachers of distance-learning courses, who could usefully employ the technology to enhance the assessment and evaluation of "site-bound" learners.

These perceived benefits associated with computer grading initiated the development of software to administer examinations. A second major source of institutional benefits was soon identified: the possibility of enhancement of student learning through frequent testing. Interestingly, the technological advance was adopted prior to knowledge of how learning could be positively affected. Hanna described the potential benefits of frequent assessment of course material:

> Perhaps the most vivid examples of the benefit of more frequent testing can be found at the college level, at which it is common for courses to have only two or three exams. In such classes it is not unusual to find students who do not 'crack the textbook' until shortly before the midterm. Rather than lament this deplorable reality, an instructor can do something to change it—test more frequently (Hanna, p. 287).

The simple, straightforward conclusion that student learning is increased with more frequent testing is based not only on common sense and experience but also on evidence (Bangert-Drowns, Kulik, and Kulik). Hanna concluded

> . . . replacing 3 50-minute tests with 15 10-minute weekly quizzes can do wonders to keep students up to pace. Although the total amount of testing time can remain the same, the impact can be great in causing students to distribute their study time more evenly. At the college level, more frequent testing can also improve attendance (Hanna, p. 287).

Therefore, online examinations may not only influence the instructional and administrative costs of teaching a large course but may indirectly affect the amount of student learning that takes place in the course by lowering the costs of administering more frequent examinations. The next two sections are devoted to a discussion of the benefits and costs of online examinations from the instructor's point of view. Analysis of student opinions follows. No firm evidence is provided that the use of online examinations results in greater levels of learning. Evidence to support this claim would require a controlled scientific experiment. Such an experiment is likely to be incompatible with teaching a real-world course characterized by equal treatment of all enrolled students. However, the instructor's assessment and experience in the use of online examinations are reported here as a guide for teachers and administrators considering the adoption and use of online examinations.

The evaluation of online testing provided here is particularly important because there are both potential costs and benefits associated with the adoption and use of this recently developed technology. Not every teacher will reach the same decision about the relative strengths and weaknesses of online testing and the likely impact on student learning. Further research could usefully undertake a controlled experiment to examine the quantitative impact of this new examination format on student learning.

Benefits of Online Examinations

The two primary benefits of administering examinations online were previously identified as the large cost savings of the substitution of machines for labor in grading and the potential for enhanced student learning due to more frequent assessment. The cost savings of online testing may not be a great deal larger than scanner examinations because a computer often grades scanner exams, with the results available quickly and efficiently. However, there are cost savings associated with the administration of online examinations and the recording and reporting of grades relative to scanner examinations. Once the software has been developed and tested, online exams replace all paper forms with digital information and labor costs with electronics, resulting in the elimination of specialized forms, equipment, and technicians for reading scanner responses, which have significant costs. Logistical and administrative issues associated with grade recording and reporting are efficiently and inexpensively handled by the computer rather than by a teacher or teaching assistant.

A third significant benefit specific to online testing is the immediate and anonymous feedback to students on homework assignments and examinations. Upon submission of the assignments and exams, the software provides students with answer keys and their own responses. According to Suen and Parkes, "The advantage of [computer-assisted testing] is the efficiency in scoring and report generation." Carlson (p. 16) concluded, "Instantaneous feedback is an excellent learning tool for the student." Rapid feedback rewards well-prepared students and can encourage students who did not perform well to increase effort levels. The linkage between student preparation and performance is a strong motivational tool, which gives students the opportunity to increase learning outcomes through expeditious and continuous knowledge of performance early in the course and throughout the semester. Kulik and Kulik summarized a meta-analysis of 254 studies with evidence that students enrolled in computer-based classes achieved higher posttest scores than those en-

rolled in traditional lecture and textbook courses. The costs associated with computer recording and reporting are significant: all gradebook functions become completely automatic and reliable.

A fourth, easily overlooked, benefit of online exams is the enjoyment and satisfaction that students receive by using the internet to look up course material and learn course material. Not only is the computer an efficient method of providing course information, assignments, and examinations, it also contributes to a learning environment that students enjoy, which can potentially lead to enhanced learning. Instructors who have administered examinations in large courses have experienced the high stress level that many students bring to the exam. A testing environment with only 30 computers dissipates this stress and fear, with an instructor and/or teaching assistant available to monitor the exam. Some of this stress reduction appears to be the smaller number of individuals and lower density (students per square foot of classroom space) taking the test, and some is undoubtedly due to the shorter exam length because exams are given over only 2 weeks of course material. Therefore, care must be taken not to attribute an improved learning environment specifically to online tests when some of the enhancement gain is most likely due to smaller test groups and shorter exam length.

The decision to adopt and use online examinations should not, of course, be determined by the degree to which students enjoy using the pedagogical tool. Careful evaluation must be made of whether student satisfaction reflects increased efficiency of learning the material (a good outcome) or a decrease in effort and level of learning (a bad outcome). While it is difficult to assess the relationships between convenience, student effort, and student preferences for an enhanced learning environment, such subjective evaluations must be considered to make effective decisions regarding pedagogical tools and examination formats.

Online examinations move exams out of the regular class time, allowing for instructors to cover more material or the same material in more depth (Barua). Giving frequent online examinations keeps the instructor involved in the student learning process by providing instant access to "item analysis," or statistical analyses of the reliability and validity of exam and assignment questions. This quantitative feedback to instructors can be extraordinarily valuable in the improvement of student assessment over time. Assignments and exams can be continuously updated and improved through the elimination of inappropriate questions and addition of new questions.

The last major benefit of online testing is the "paperless" aspect of computer assignments and examinations. Placing course material online results in significant cost savings because paper, copying, and distribution expenses are all reduced or eliminated. The elimination of paper costs alone is extraordinary. The copying and distribution of assignments to a large class is often unwieldy and inefficient. Administrators anxious to reduce expenditures are likely to strongly favor the transition from paper assignments and examinations to online learning opportunities. There are, however, significant costs associated with the implementation of online examinations, as identified and assessed in the next section.

Costs of Online Examinations

Perhaps the largest issue associated with online examinations is the potential for dishonesty and/or cheating (Barua). Carlson (p. 16) bluntly stated, "... the opportunity for academic dishonesty abounds." If examinations are placed online, students could cheat in several ways, including (1) using unauthorized books, lecture notes, or other course material, (2) getting help from an individual or group, (3) taking more time than allocated, or (4) viewing the questions before studying. These issues were dealt with at Kansas State University by the development of a computer laboratory exclusively devoted to online testing (Barua reported that the same technique was used at the University of Akron, and Pyle developed a testing laboratory at Concordia College).

The laboratory at Kansas State University

has 30 computers connected to the internet. During the first week of class, students signed up for 30-minute appointments to take exams every 2 weeks throughout the semester. The instructor and two teaching assistants matched students with photo IDs and administered the examinations. During the initial software development period, the examination process was labor-intensive. This was to ensure a positive atmosphere for test taking and an efficient, fair, and safe environment. As more online test experience was gained, labor costs fell rapidly as confidence was gained in the hardware, software, and logistics associated with administration of online exams. The labor costs of online exams are significant and include (1) software development, if a program is not purchased, (2) bureaucratic costs of acquiring an appropriate computer laboratory for online examinations, and (3) examination administration costs. Proctoring costs are significant because exams are taken in small groups. These costs will diminish when larger computer laboratories become available.

Users of online testing technology must be cautious to ensure that the test website is completely secure. Also, when exams are given in small groups at different times, thought must be given to the possibility of students who take the exam early sharing the questions (or answers) with students who take the exam later. This does not present a major problem in the current class because students are expected to know all of the material and previous exam questions are made available to students on the internet. Thus, students know the general content of the exam questions prior to the exam. Specific questions, however, are not known. As a result, students are not allowed to take any materials out of the exam room to discourage this form of cheating. Similarly, exam answer keys and student responses are not made available until all students have taken the exam.

Development costs can be avoided by the adoption of one of several software packages available for college courses (Gibson et al.). As these packages become more widely used, their quality and usefulness improve rapidly. Finding space to develop a test location can be time-consuming and frustrating. However, as administrators and faculty learn about the potential gains from computer-based testing, these bureaucratic hurdles are likely to diminish.

The large benefits of online examinations are likely to outweigh the additional costs of computer testing, based on the subjective experience of the author. Because online testing represents a new technology, the costs associated with adoption can be high. However, these costs are likely to dissipate over time. One limitation of this research is that empirical estimates of the actual costs and benefits of online examinations are not provided. These benefits and costs differ for each course and instructor. It is likely, however, that the costs of using online tests will decrease over time as more teachers adopt the technology. The next section reports on student perceptions and experiences with online examinations.

Student Analysis of Online Testing: Data Description

Computer examinations were administered biweekly to two introductory Principles of Agricultural Economics and Agribusiness courses in Spring 2000 (175 students enrolled) and Spring 2001 (144 students enrolled). Survey data were collected from students enrolled in these two classes. Information concerning student opinions on computer testing was collected as an in-class assignment during the last week of the semester. Student responses to several questions on online assignments and examinations were then merged with data on student grades for analysis, as described below.

One limitation of this study is that the responses were not anonymous because student names appeared on the top of the assignment/questionnaire. The lack of anonymity was purposeful; the benefits of matching answers with grades were considered greater than the bias resulting from lack of anonymity. It is important to note that the assignment score was not impacted by the student responses. All students who completed the assignment were giv-

Table 1. Survey Results of Student Preferences for Computer Assignments and Exams[a]

Student response to survey statement:	Agree (%)	Disagree (%)
"I prefer homework assignments on the computer to homework assignments on paper."	280 (93)	21 (7)
"I prefer taking exams on the computer to taking exams on paper."	244 (81)	57 (19)
"I prefer six short exams every two weeks to three long midterm exams."	293 (97)	8 (3)
"I prefer taking exams outside of class time to taking exams in class."	161 (53)	140 (47)
"I like taking quizzes every Friday."	146 (49)	155 (51)

[a] A survey of 301 students enrolled in AGEC 120, Principles of Agricultural Economics and Agribusiness, at Kansas State University, Spring Semester 2000 and 2001. The response rate was 94%.

en full credit. Course grades were not influenced by student responses. The course grade was calculated from objective numerical scores on multiple-choice assignments and examinations.

The objectives of this research are subjective and limited by the nature of the data available for study. Specifically, quantitative evidence of the impact of the use of online examinations on student learning and student satisfaction levels is beyond the scope of this research. This type of evidence would necessitate experiments that divide the class into two identical groups: a control group and a group that used online examinations. Student differences in ability, experience, and learning style would have to be accounted for (held constant). This rigorous experimental design would provide some evidence on student learning outcomes and the effect of online testing on cognitive processes. However, this type of experiment would be undesirable in a real-world freshman-level course in Principles of Agricultural Economics, as it would violate principles of equal treatment and fairness. These values are highly valued by instructors and students. Therefore, the goals of the present research are to provide a subjective assessment and evaluation of one instructor's use of online examinations in an attempt to provide useful information to potential users of online examinations.

Responses to survey questions are summarized in Table 1. The first question concerned homework assignments and was included to compare student opinions on online assignments to preferences for online examinations. An overwhelming majority (93%) of surveyed students preferred weekly computer homework assignments to paper assignments, providing evidence that most students find online learning attractive. Similarly, a large majority (81%) of students preferred computer exams to paper exams. Previous research has found that frequent assessment can potentially lead to higher levels of student learning (Bangert-Drowns, Kulik, and Kulik). Interestingly, 97% of all students enrolled in two Principles of Agricultural Economics courses preferred six short exams every 2 weeks to three long midterm exams. Hanna reported that, ". . . students themselves tend to favor more frequent testing" (p. 287). To the extent that online examinations lower the costs of providing frequent tests, the outcome of online testing could promote enhanced learning levels.

Online examinations were conducted outside of regular class time. While this can be considered to be a benefit from the instructor's point of view (Barua), many students were less enthusiastic. Only a small majority (53%) preferred taking exams outside of class time. Discussions with students led to the conclusion that this is typically due to busy schedules that include courses, work, and labs. Every Friday, students enrolled in AGEC 120 were subjected to an in-class quiz covering the material presented during the week. Survey responses demonstrated that approximately one half (49%) of all surveyed students "like tak-

ing quizzes every Friday." This result is a striking contrast to the strong support for online exams. The determinants of student preferences for online examinations will be evaluated in the next section.

Empirical Model: The Determinants of Student Opinion on Online Testing

To further understand student opinions concerning online testing, an empirical model was developed to identify and quantify the determinants of the student opinions reported in Table 1. Because the survey information was gathered in a qualitative fashion (1 = agree; 0 = disagree), logistic regression was used to estimate the determinants of student opinions on online testing (Greene). The empirical model is specified in equation (1) for individual i's response to the five survey questions (j = 1, . . . , 5) reported in Table 1,

$$(1) \quad \text{OPINION}_{ij} = f(\text{COMPSKILL}_i, \text{YEAR2000}_i, \text{STUDY}_i, \text{YEAR}_i, \text{GRADE}_i, \text{MAJOR}_i).$$

Self-reported computer skills (COMPSKILL) reflect agreement or disagreement with the survey question, "I have excellent computer skills." Carlson (p. 18) stated, "Students who view the online environment and technology as a way to enhance their learning experience will usually perform better when tested than the students who have fear and trepidation about the delivery method of the course."

To test for potential differences between years, a qualitative variable (YEAR2000) was included (1 if year = 2000; 0 if year = 2001). Differences in student attitudes are likely to differ in the second year of online testing (2001) because information about the course and the exam format was available to these students from their peers prior to enrollment. This knowledge was unavailable to students who enrolled in 2000, the first year of online testing. Therefore, it is likely that self-selection of students who are less comfortable with computers occurred because another section of the course that does not use online examinations is offered each Fall semester.

Students who were well prepared may prefer all aspects of the course, including exam format, better than less prepared students. To test for this possibility, the self-reported number of hours studied per week (STUDY) was included in the regression analysis. The mean number of hours studied per week was 2.68, with a standard deviation of 1.4 (see Gortner and Zulauf and Kember et al. for two interesting studies of the use of time by students).

Student performance was expected to influence student opinion of assessment type. To account for this, student grades (GRADES) on exams, assignments, and quizzes were included as a separate variable in each regression. These variables reflect actual grades as opposed to the self-reported variables COMPSKILL and STUDY. The included grades were predetermined and exogenous because all of the assignments, exams, and quizzes were administered prior to the survey date. The comprehensive final exam score was not included in the regressions because the final exam occurred after the survey date. Mean exam grades equaled 74.95, with a range from 39.75 to 95.25 (Table 2). Quiz and assignment grades were similar but slightly higher than exam grades (Table 2). The student's major field of study (MAJOR) and year in school (YEAR) were also included as independent variables.

It was anticipated that grades on assignments, quizzes, and examinations may be highly correlated, leading to the potential for collinearity. Correlations between grade variables were calculated and are reported in Table 3. Interestingly, grades for different assessment types are not highly correlated, ranging from .40 to .72. This result is important and interesting because it provides evidence that student performance differs across assessment tools, perhaps due to differences in learning styles. While this result is not new, it does reinforce the idea that a variety of performance tools may be appropriate for college courses. This unanticipated result suggests that an improved experimental design could have incorporated the impact of student learning styles on their preferences for online examinations. Future research could use available learning-style inven-

Table 2. Summary Statistics of Variables Used in Regressions of Computer Exams

Variable	Mean	SD	Minimum	Maximum
Computer skills (COMPSKILL)[a]	0.68	—	0	1.00
YEAR2000 (2000 = 1; 2001 = 0)	0.55	—	0	1.00
Hours studied per week (STUDY)[b]	2.68	1.40	0	8.50
Year in school (YEAR)				
Freshman[c]	0.42	—	0	1.00
Sophomore	0.28	—	0	1.00
Junior	0.19	—	0	1.00
Senior	0.11	—	0	1.00
GRADES (percent)				
Exams	74.95	10.55	39.75	95.25
Assignments	83.05	9.74	20.00	97.91
Quizzes	80.46	10.87	30.00	98.05
Major field of study (MAJOR)				
Undecided	0.04	—	0	1.00
Agribusiness	0.08	—	0	1.00
Agricultural Economics	0.09	—	0	1.00
Agricultural Education	0.04	—	0	1.00
Agricultural Journalism	0.03	—	0	1.00
Agricultural Tech. Management	0.06	—	0	1.00
Agronomy	0.07	—	0	1.00
Animal Sciences and Industry[c]	0.24	—	0	1.00
Bakery Science and Management	0.01	—	0	1.00
Feed Science and Management	0.02	—	0	1.00
Food Science and Industry	0.003	—	0	1.00
Horticulture	0.07	—	0	1.00
Horticultural Therapy	0.01	—	0	1.00
Milling Science and Management	0.06	—	0	1.00
Park Resource Management	0.003	—	0	1.00
Pre-Veterinary Medicine	0.07	—	0	1.00
Other	0.05	—	0	1.00
Business	0.02	—	0	1.00
Engineering	0.01	—	0	1.00
Arts and Science	0.02	—	0	1.00

[a] Response to statement "I have excellent computer skills." Agree = 1; disagree = 0.
[b] Student response to survey statement "Average number of hours PER WEEK spent studying AGEC 120 this semester (please be as accurate as possible!)."
[c] Default category omitted from the logistic regression analysis.

tories to measure this important and interesting relationship. Table 3 also shows stronger correlations (.74 to .94) between the assignment, quiz, midterm exam, final exam grades, and course grade (GRADE). This result simply reflects that the course grade is a weighted average of the other grades.

Results

Logistic regression results appear in Table 4 for each of the five survey questions reported in Table 1. As in all statistical models, the regression results are subject to the possible limitations of misspecification error, data measurement error, and spurious correlation. The first regression explores student preferences for computer assignments. Positive coefficients indicate agreement with the statement that computer assignments are superior to paper assignments. Students enrolled in AGEC 120 in Spring 2001 preferred computer assignments significantly more than those enrolled in Spring 2000 (YEAR2000). This could reflect broader

Table 3. Correlations of Grade Variables Used in Analysis of Computer Exams

	Pearson Correlation Coefficients[a]				
	ASSIGN[b]	QUIZ[c]	EXAM[d]	FINAL[e]	GRADE[f]
ASSIGN	1.00	.65	.59	.40	.76
QUIZ	—	1.00	.72	.43	.84
EXAM	—	—	1.00	.66	.94
FINAL	—	—	—	1.00	.74
GRADE	—	—	—	—	1.00

Note: Number of observations = 301.

[a] All of the correlation coefficients are statistically significant at greater than the 0.01 level.

[b] Average grade on weekly online assignments (percent).

[c] Average grade on weekly in-class quizzes (percent).

[d] Average grade on biweekly computer examinations (percent).

[e] Grade on comprehensive final examination (percent).

[f] Course grade, a weighted average of the other reported grades (percent).

acceptance of computers over time or self-selection of students uncomfortable with computers outside of the course. Self-selection is likely because no information concerning student experiences with online examinations was available to students who enrolled in 2000. This information was available to students in 2001 from students who had taken the course in 2000. A student who was uninterested in using computers could choose to take the same course offered in the Fall with no computer assignments and/or examinations.

Weekly study hours (STUDY) were positively associated with a preference for computer assignments, indicating that well-prepared students preferred computer assignments. The variables MAJOR and YEAR were not statistically associated with the preference for computer versus paper assignments. The only other statistically significant variable was assignment grades (ASSIGNS), which was positively associated with a preference for computer assignments. This reflects the idea that those who did well on computer assignments relative to other students liked the assignments.

The second column in Table 4 reports logistic regression results for student preferences for computer examinations. Students in 2001 preferred computer examinations relative to those enrolled in 2000, and those who studied more hours per week preferred computer exams relative to those who studied fewer hours per week. Predictably, students who earned higher examination grades (EXAMS) were more likely to prefer computer assignments than those with lower exam grades. Interestingly, however, students with higher assignment grades (ASSIGNS) preferred computer exams less than those with lower assignment grades at a high level of statistical significance. This may reflect differences in learning styles, as captured by the low correlation coefficient (.59) between assignment grades and exam grades (Table 3). Borcher et al. found that personality tests and temperament/learning style can influence student performance.

The logistic regression for student preference for six short exams or three long midterm exams is not as significant as the other regressions, based on a relatively low and statistically insignificant log-likelihood value (73.83). However, the regression has high predictive ability (96.6% concordant observations) because 293 out of 301 responding students preferred more frequent examinations. Students with more study hours (STUDY) favored six shorter exams relative to those who studied fewer hours. Students who did well on the examinations (EXAMS) preferred six short exams relative to those with lower exam grades. Students enrolled in Agricultural Journalism, Agronomy, and Arts and Sciences were less enthusiastic about six short exams relative to students enrolled in the default major of Animal Sciences and Industry. This may reflect small-sample bias because a small num-

Table 4. Logistic Regression Results of Student Preferences for Computer Exams[a]

	Parameter Estimates				
Variable	Prefer Computer Assignments	Prefer Computer Exams	Prefer Six Short Exams	Prefer Outside Exams	Like Weekly Quizzes
INTERCEPT	−2.49 (2.31)	3.82 (1.85)**	−1.57 (4.84)	−0.68 (1.25)	−1.42 (1.35)
COMPSKILL	0.60 (0.58)	−0.05 (0.35)	1.12 (1.01)	0.53 (0.27)**	−0.16 (0.27)
YEAR2000	−1.46 (0.67)**	−0.99 (0.38)***	0.54 (0.97)	0.19 (0.27)	−0.47 (0.27)*
STUDY	0.63 (0.30)**	0.33 (0.14)**	1.84 (0.96)**	0.11 (0.10)	0.11 (0.10)
Year in school (YEAR)					
SOPH	−0.48 (0.65)	−0.37 (0.40)	2.33 (1.52)	−0.02 (0.31)	0.35 (0.31)
JUNIOR	−0.89 (0.76)	−0.24 (0.45)	13.12 (165.8)	−0.30 (0.35)	0.37 (0.36)
SENIOR	0.84 (1.19)	−0.44 (0.57)	−1.47 (1.25)	0.09 (0.45)	−0.09 (0.47)
Grades					
EXAMS	−0.004 (0.04)	0.04 (0.02)*	0.17 (0.10)*	−0.02 (0.02)	−0.05 (0.02)**
ASSIGNS	0.10 (0.04)***	−0.05 (0.03)**	−0.03 (0.06)	0.01 (0.02)	−0.002 (0.02)
QUIZZES	−0.05 (0.04)	−0.02 (0.03)	−0.10 (0.11)	0.01 (0.02)	0.06 (0.02)***
Major field of study (MAJOR)					
UNDECIDED	−0.83 (0.96)	−0.09 (0.79)	9.17 (455.8)	−0.16 (0.63)	−0.60 (0.66)
AGRIBUS	1.63 (1.15)	1.30 (0.83)	9.94 (294.2)	0.23 (0.49)	0.13 (0.49)
AG ECON	1.26 (1.19)	0.23 (0.66)	9.10 (300.4)	−0.14 (0.47)	−0.14 (0.47)
AG EDUCAT	−0.02 (1.27)	−0.55 (0.75)	−3.38 (2.22)	−0.26 (0.66)	0.07 (0.69)
AG JOURN	−1.69 (1.10)	−1.10 (0.85)	−5.73 (2.63)**	−0.02 (0.74)	−0.40 (0.75)
AG TECH	12.96 (287.1)	0.46 (0.75)	9.91 (384.1)	−0.31 (0.56)	−0.32 (0.56)
AGRONOMY	13.05 (252.4)	−0.47 (0.58)	−3.72 (1.96)*	−0.34 (0.51)	−0.43 (0.51)
BAKERY SCI	11.62 (825.4)	13.00 (926.6)	6.99 (1103)	−15.62 (1157)	−0.99 (1.27)
FEED SCI	12.35 (557.5)	13.63 (599.4)	8.81 (612.1)	0.14 (0.82)	0.39 (0.84)
FOOD SCI	11.45 (1560)	12.60 (1630)	−5.94 (1946)	15.76 (2009)	4.77 (2003)
HORT	11.97 (276.3)	1.34 (0.88)	−1.97 (1.81)	−0.35 (0.53)	−0.15 (0.54)
HORT THER	−0.54 (2.34)	−2.38 (1.63)	7.11 (1197)	−14.85 (1420)	15.62 (1404)
MILL SCI	0.88 (1.22)	−0.26 (0.68)	−2.50 (1.92)	1.46 (0.69)**	−0.16 (0.54)
PARK RES	12.15 (1560)	13.02 (1630)	13.97 (1939)	15.32 (2009)	14.67 (2003)
PREVET	0.49 (1.02)	−0.32 (0.60)	10.00 (308.4)	−0.98 (0.54)*	0.68 (0.54)

Table 4. (Continued)

Variable	Parameter Estimates				
	Prefer Computer Assignments	Prefer Computer Exams	Prefer Six Short Exams	Prefer Outside Exams	Like Weekly Quizzes
OTHER	12.18 (274.2)	0.98 (1.12)	8.79 (376.9)	0.44 (0.62)	−1.61 (0.72)**
BUSINESS	0.10 (1.24)	−0.09 (0.92)	9.24 (611.4)	−0.49 (0.83)	−1.66 (1.15)
ENGINEER	13.92 (1043)	13.39 (1149)	−2.33 (1270)	15.27 (1419)	−0.34 (1.49)
ARTS SCI	12.29 (565.1)	0.20 (1.19)	−5.63 (2.55)**	−0.85 (0.97)	−1.44 (1.18)
−2 LOG L	152.338***	292.15*	73.83	415.808	417.01
% CONCORDANT	88.4	75.1	96.6	68.2	68.1

[a] Number of observations = 301. Standard errors are in parentheses.
*** Significance level = .01.
** Significance level = .05.
* Significance level = .10.

ber of observations (eight) indicated a preference for three long midterm exams.

The fourth regression reports results for student preferences for taking examinations outside of regular class time. This regression is of particular interest because the students were nearly evenly split on their preference for outside exams. Students with self-reported excellence in computer skills (COMPSKILL) were statistically associated with a preference for exams outside of class. This result demonstrates a significant relationship between student ability to use a computer and preference for online examinations. This is a concern for instructors considering adoption of online examinations. However, the level of computer competence necessary to take the exams is rudimentary. As computer skills increase over time, this concern is likely to dissipate in the future.

Milling science majors (MILL SCI) preferred outside exams, while preveterinary (PREVET) students did not. These results demonstrate that students from similar backgrounds or majors may share similar opinions, either due to self-selection of like-minded individuals into the same major or due to consensus building by individuals within the group of majors.

The fifth regression reports the statistical determinants of student preferences for weekly in-class quizzes, which were administered on paper. Students enrolled in Spring 2000 showed a statistically significant dislike of weekly quizzes relative to students enrolled in Spring 2001. Students enrolled in other majors (OTHER) than those listed in Table 2 demonstrated less approval of weekly quizzes than students in Animal Sciences and Industry (the default category). Following the pattern of the other regressions, students who performed well on the weekly quizzes (QUIZZES) were associated with stronger preferences for the quizzes than those with lower quiz grades. Conversely, students with higher exam grades (EXAMS) were less likely to prefer quizzes than those with lower exam grades.

Implications and Conclusions

While this study has not quantified evidence for improvements in learning environments

and the level of learning, the survey results demonstrated a strong preference for computer assignments and examinations relative to traditional examinations and a strong preference for frequent examinations. It is the subjective belief of the instructor that student learning was enhanced due to the use of online examinations, but this result could have been due to the less stressful examination environment or shorter examinations. Further research could usefully quantify the relationships between examination format, test length, student learning styles, and the amount of student learning.

Students enrolled in the second year of online exam use (2001) had stronger preferences for online course assessment tools than the first year. This is likely to have resulted from less uncertainty about the course in the second year and self-selection of students who are attracted to computers into the course over time. Students with higher levels of self-reported computer skills preferred exams given outside of class time relative to those with less confidence in their computer skills.

Students who worked harder in the two courses, as measured by a higher number of self-reported study hours per week, preferred computer assignments, examinations, and exam times outside of lectures. This result affirms that the new technology of online testing is preferred by harder working students but may provide a warning that less well-prepared students may have more trouble in a course that uses computers than in a traditional course. This implication deserves serious consideration. Students in some majors preferred online testing more or less than other majors, but it is difficult to find a consistent pattern in these results. The results indicate that people in the same major can share similar opinions about the new technology. The year in school was statistically unrelated to student preferences for online exams and assignments.

Students who performed well with one type of assessment tool (assignments, exams, and quizzes) indicated a preference for that assessment tool and a dislike for other forms of assessment. The relatively low correlation coefficients calculated for different assessment tools reveal that student performance is not uniform across assessment types. This result is important and interesting, as it provides some evidence that the choice of assessment tool can influence student performance, perhaps due to differences in learning styles. One implication of this result is that a variety of assessment tools may be appropriate to reach a group of diverse students in an entry-level course.

One way to provide a portfolio of assessment tools is the adoption and implementation of online examinations (Haney and Madaus). Gilbert pointed out that adoption and use of a new technology such as online examinations not only provides information about the technological innovation itself but can also provide valuable information about how students learn and about learning outcomes. The adoption and use of online examinations has provided insight into how students learn, which is perhaps the most important conclusion of this research. Any change in instructional style is likely to provide useful information about how a course could be improved.

The experience of adopting online examinations in this particular course has yielded several strategies that could enhance the future use of computer testing. First, careful evaluation of any change in a course allows an instructor to rethink how to improve the learning environment and how to increase student learning. The experience with computer testing suggests that (1) rapid feedback on assignments and tests, (2) testing environments, and (3) exam length and frequency are all course components that exhibit opportunities for improving learning outcomes. A variety of assessment tools may promote learning across a greater variety of learning styles, and online assignments and tests could be one component of a portfolio of assessment formats.

Second, the use of currently available software can reduce the large costs of development and implementation. Importantly, success with online exams is more likely if instructors have the approval of and support from administrators in their own unit as well as in the computing department. Acquiring and utilizing physical space for a testing fa-

cility can be time-consuming and frustrating without such support. Careful comparison and consideration of the costs and benefits associated with available test formats (essay, scan technology, online tests, etc.) is highly recommended. These costs and benefits are likely to differ for each instructor and each course. The costs of online testing and computer laboratories are likely to decrease rapidly as the technology becomes more available, standardized, and utilized.

Third, students should be made aware of the motivation behind computer testing and why it has been adopted in order to dispel fears and concerns about trying something new. The possibility of cheating must be carefully addressed by making sure the website is secure and to account for students who could share answers with others who take the exam at a later time.

Finally, in many cases, cost savings can be realized by shifting away from paper tests that require grading, either by hand or machine, to computer-graded tests that grade, record, and report scores instantly, anonymously, and accurately. However, the costs of online testing include dedicated equipment, space, and personnel. Given the experience of this instructor, it appears likely that, over time, (1) the benefits of online testing will increase relative to the costs, (2) an increasing number of teachers will adopt and use computer examinations, and (3) the online exam format will continue to be enhanced and improved.

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References

Bangert-Drowns, R.L., J.A. Kulik, and L.C. Kulik. "Effects of Frequent Classroom Testing." ERIC Document Reproduction Series No. 274-672. Paper presented at the 67th Annual Meeting of the Research Association, San Francisco, CA, April 16–20, 1986. Internet site: http://edrs.com/ (Accessed March 25, 2002).

Barkley, A.P. "Unanticipated Benefits from the Use of Computer Technology in a Large Introductory Course." *Interactive Learning: Vignettes from America's Most Wired Campuses.* David G. Brown, ed. Bolton, MA: Anker, 2000.

———. "The Future of Teaching Undergraduate Agricultural Economics: Lifelong Learning in an Era of Rapid Technological Change." *Journal of Agricultural and Resource Economics* 26(July 2001):1–19.

Barkley, A.P., and A. Haycock. "Development and Use of the Homework Helper, an Online Homework Grader." *NACTA Journal* 45(March 2001):27–32.

Barua, J. "Computer-Based Testing on Campus." *Syllabus* (April 1999):51–52.

Borcher, G., B. Pinckney, and E. Clemens. "Temperament Learning Styles Associated with True/False, Multiple Choice, and Multiple-Multiple Choice Exam Formats." *NACTA Journal* 38(March 1994):10–12.

Bracey, G.W. "Teachers, Thinking, and Testing." *Phi Delta Kappan* 71(January 1990):404–7.

Carlson, R. "Assessing Your Students: Testing in the Online Course." *Syllabus* (March 2000):16–18.

Gibson, E.J., P.W. Brewer, A. Dholakia, M.A. Vouk, and D.L. Bitzer. "A Comparative Analysis of Web-Based Testing and Evaluation Systems." Internet site: http://waltoncollege.uark.edu/disted/ (Accessed March 25, 2002).

Gilbert, S.W. "Making the Most of a Slow Revolution." *Change: The Magazine of Higher Learning* 28(March/April 1996):10–23.

Gortner, A.K., and C.R. Zulauf. "The Use of Time by Undergraduate Students." *NACTA Journal* 44(March 2000):22–30.

Green, K.C. "The Coming Ubiquity of Information Technology." *Change: The Magazine of Higher Learning* 28(March/April 1996):24–31.

Green, K.C., and S.W. Gilbert. "Great Expectations: Content, Communications, Productivity, and the Role of Information Technology in Higher Education." *Change: The Magazine of Higher Learning* 27(March/April 1995):8–18.

Greene, W.H. *Econometric Analysis,* 2nd ed. New York: Macmillan Publishing Co., 1993.

Haney, W., and G. Madaus. "Searching for Alternatives to Standardized Tests: Whys, Whats, and Whithers. *Phi Delta Kappan* 70(May 1989): 683–87.

Hanna, G.S. *Better Teaching Through Better Measurement.* New York: Harcourt Brace Jovanovich Publishers, 1993.

Kember, D., Q.W. Jamieson, M. Pomfret, and E.T.T. Wong. "Learning Approaches, Study Time, and Academic Performance." *Higher Education* 29(1995):329–43.

Kulik, C., and J.A. Kulik. "Effectiveness of Computer-Based Instruction: An Updated Analysis." *Computers in Human Behavior* 7(1991): 75–94.

Newman, M.E., M.P. Ram, and T.M. Day. "The Effects of World Wide Web Instruction and Traditional Instruction on Achievement and Change in Student Attitudes in a Technical Writing in Agricommunication Course." *Proceedings of the 1996 National Agricultural Education Research Meeting* 23(1996):80–90.

O'Kane, M., and J.D. Armstrong. "Developing Course Materials Using the World Wide Web." *NACTA Journal* 41(June 1997):10–15.

Pyle, J. "Perception On-line Testing and Tutorials." Concordia Computing. Internet site: www.cord.edu/dept/computing/faculty/tools/perception (Accessed March 25, 2002).

Suen, H.K., and J. Parkes. "Challenges and Opportunities in Distance Education Evaluation." Distance Education Resource Center. Internet site: http://waltoncollege.uark.edu/disted/challenges_and_opportunites_in_.htm (Accessed March 25, 2002).