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Articles

The Effect of Access Time on Online Quiz Performance in Large Biology Lecture Courses

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To better understand the dynamics of online student test taking, including the likelihood of cheating by large numbers of students, we examined test-taking patterns and outcomes of weekly online quizzes in two large undergraduate biology lecture courses. Students taking a quiz late in a 1–3-day quiz access period performed 10–15% worse on quizzes than the students who completed the quiz early. Quiz access time was also negatively correlated with performance in other course components and course grades. These patterns suggest that academic dishonesty was not a determinant in unsupervised online quiz performance. Students generally completed quizzes in late afternoon or evening hours, but students who completed quizzes between midnight and 8 a.m. had significantly lower quiz grades than their peers. In addition, upper-division students were more likely to characterize weekly online quizzes as more helpful for their learning than the lower-division students.

Keywords: Biology, cheating, web-based instruction, online examination.

The use of online course management systems (CMS)[1] such as Blackboard, WebCT, and Moodle is becoming more common in higher education. In spring 2007, Montana State University (MSU), Bozeman, offered 299 courses on campus with a CMS component and 59 distance education courses delivered via CMS. Over 8,800 of MSU's 12,000 students (73%) had at least one course that used Web-CT in the school year 2006–2007. In this article, we examine student performance on weekly, graded, online quizzes in two large biology lecture courses. We hypothesized that the majority of students would access the quiz late in the access period, and also hypothesized that average scores would increase over the access period as early quiz-takers shared information about quiz content with fellow students.

Web-based activities, including online quizzes, can increase student performance in a course, suggesting that these activities are worthwhile. DeSouza and Fleming show that students who practice for exams using online quizzes outperform peers who take traditional paper and pencil quizzes [1]. Freeman *et al*. [2] indicate that online graded practice exams, as part of a strategy of active learning exercises, increase the performance of students in introductory biology, especially those at high risk for failing the course. Riffell and Sibley [3] also show that hybrid course formats that use online assignments to promote active learning improve student performance. Web-based activities also provide greater flexibility for students to choose when they will complete activities, and may increase student learning by increasing the participation in course activities [4, 5].

One great concern in using online assignments, particularly online testing, is the potential for academic dishonesty. Even in the absence of computers, it is clear that cheating is prevalent in our educational system [6]. At least 70% of high-school students admit to having cheated [7]. More recent studies commissioned by the Educational Testing Service (ETS) indicate that 86% of high-school students and 73% of ETS test takers (including prospective graduate students) believe that cheating occurs [8]. The question is: does having students complete assignments online, rather than within the classroom, leads to a higher incidence of cheating?

Two arguments are generally made regarding the validity of online testing. Proponents suggest that built-in safeguards in CMS software (such as student passwords, limiting the number of exam attempts, and implementing time limits) ensure the integrity of the process, while opponents argue that students will simply take online tests as a group or share information between students, making assessment of an individual student achievement impossible [9, 10].

The incidence of cheating on quizzes and exams given via CMS is understudied. Plowman [11] takes a positive view, suggesting that a CMS can function as a learning aid to stimulate student interest, engaging the student and thereby decreasing their desire to cheat. However,

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[1] The abbreviations used are: CMS, course management systems; MSU, Montana State University; ETS, Educational Testing Service.

surveys by Kennedy *et al.* [12] suggest that a majority of faculty and students perceive that students will cheat more on unsupervised online assignments in an electronic course than a regular course. Charlesworth *et al.* also surveyed student perceptions of cheating on online exams. While 45% of students agreed to the question that online quizzes would increase cheating relative to students taking those exams in a classroom setting, 87% of students surveyed also indicated that they would "only hurt themselves" by cheating in this manner, and 84% disagreed with the statement that "online quizzes and exams increase my desire to cheat." Seventeen percent of the students in a hybrid course (part classroom-based, part Internet-taught) surveyed for the study admitted to cheating on online assignments previously in their career [13].

Directly quantitating the incidence of cheating in any particular course, especially one in which the students being surveyed are currently enrolled, can be difficult, if not impossible. Using a complex randomized response survey tactic to assure student anonymity, Grijalva *et al.* [14] estimated the incidence of cheating in online classes at 3%, well within findings in a small number of similar studies that estimate the cheating rates in traditional classrooms at 2–13%. This suggests that cheating on online assignments is not necessarily more prevalent than in classroom-based courses.

In this study, we investigated the pattern of student performance on online quizzes where students were allowed to choose the time and place of access, and were therefore unsupervised while taking the quiz. We examined what times within the allotted access period were most frequently chosen by students to complete the quiz task, how average quiz performance varied over time, and how quiz performance correlated with performance in other aspects of the course. Students were also surveyed to gauge their perceptions of online quizzes as part of the course design.

METHODS

Course Design

Students in advanced cell biology (biology 302; an upper-division required course) in spring 2007 ($N = 90$) and a second-semester introductory biology course (biology 214; a lower-division required introductory-level course covering cell biology and genetics) in fall 2007 ($N = 125$) were given weekly, graded, online quizzes. Quizzes covered lecture material from the previous week as well as assigned reading. In both courses, online quizzes were administered via the Web-CT CMS (Blackboard, Washington, DC).

The quiz access period for introductory biology was 72 hours in length. Students could start the quiz at any time within the access period. Once the quiz was started, students had 20 min to complete the quiz. Students could access the quiz only one time. Scores and quiz answers were posted after the quiz access period had expired. Eleven quizzes were given over 15 weeks, and each student's lowest quiz score was dropped in the final grade calculation. Online quiz performance represented 10% of the overall course grade.

Administration of quizzes in advanced cell biology was identical to introductory biology, except the quiz access period was only 24 hours in length. Twelve quizzes were given over 15 weeks, and the top nine quizzes were used in calculating each student's final grade. The online quizzes represented 12% of the overall course grade.

Quiz Design

Students were allowed to access the quiz from any computer with internet access, and each student entered the quiz via the Web-CT portal using their university-assigned Web-CT ID and their own password. The 10 questions for each student quiz were pulled from a larger question bank, consisting of 15–30 items, depending on the course and week. The CMS generated unique quizzes from the test bank for each student. Questions were furthermore designed by the instructor to cover varying levels of Bloom's taxonomy of educational objectives [15], with three of 10 questions requiring students to engage in higher order thinking skills. For these more difficult questions, students were required to synthesize information, draw a conclusion, or perform a calculation. The CMS allows different questions for the quiz to be drawn from instructor-designated subsets of the question bank. Careful quiz design was therefore utilized to provide each student with a quiz that was both unique and comparable in difficulty to the quizzes taken by other students within the testing period.

Data Analysis

Individual student quiz entry times, as recorded by the CMS, were matched to student scores for each quiz. Entry times were scored for the number of the hour during the access period that the student began the quiz (1–72 for introductory biology; 1–24 for advanced cell biology). Quiz data for each student was matched to that student's final course grade. Once data was compiled, student-identifying information was removed from the data set prior to analysis. For introductory biology, three quizzes of the 11 were removed from the analysis, because they were either practice quizzes with unlimited access (in two instances), or a course evaluation survey (in one instance). For advanced cell biology, four of 12 quizzes were removed from the analysis because students were given unlimited access (two instances), had only 12 hours of access rather than 24 (one instance), or received full credit for completing a course evaluation survey (one instance). Quiz scores were on a scale from 1 to 10. Course letter grades were converted to a 4.0 scale for analysis.

For percentile rank analysis, the spread of student quiz scores were transformed to a scale of 0–100%, where 0% represented the lowest student average quiz score and 100% the highest average student quiz score. The same method was used to transform student final course point percentages to a scale of 0–100%. The contribution of quiz scores to final course point percentages were removed prior to this analysis. Only data for students who received a course grade of C (1.67) or better were included in this analysis, as most students who received nonpassing grades were missing a large number of quiz scores. All statistical data analyses were performed with Minitab v.15 statistical analysis software (Minitab, State College, PA).

Online Quiz Satisfaction Survey

To determine if students perceived the weekly quizzes as helpful to their learning, students in both courses were asked to fill out an anonymous, open-response survey on the CMS. Responses were sorted into categories and tabulated. For advanced cell biology, 86 survey respondents provided 94 separate comments. In introductory biology, 117 respondents provided 140 separate comments.

RESULTS

In a student population accessing online quizzes over a 1–3-day period, students' quiz scores are negatively

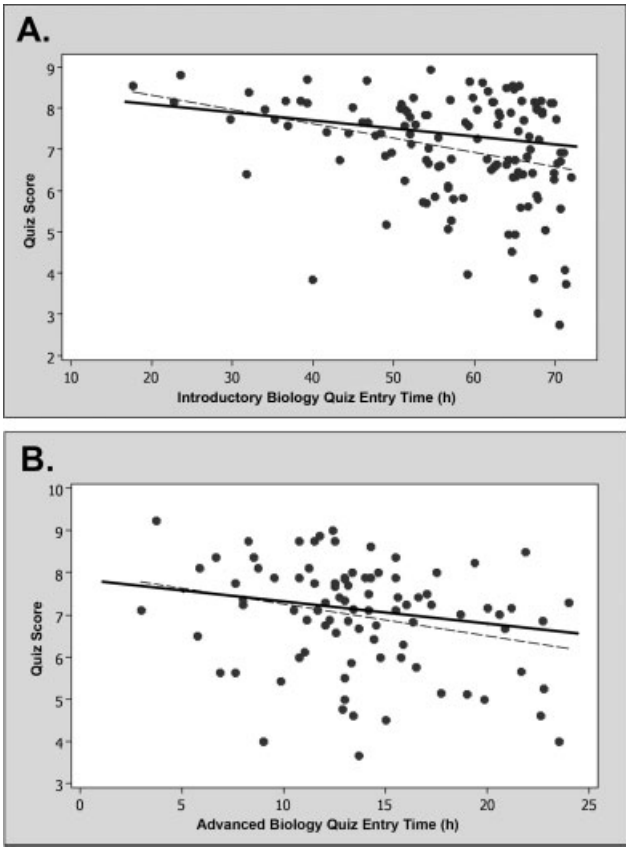

FIG. 1. **Effect of quiz access time on quiz grade.** (*A*) Introductory biology (72-hour quiz access periods). Solid line: Regression line for quiz access time versus quiz grade for all quizzes completed in the course (individual data points not shown); $N = 1{,}036$, $R^2 = 2.1\%$, $p < 0.0005$. Dashed line: Regression line for average quiz score versus average access time for each student (•). $N = 125$, $R^2 = 9.7\%$, $p < 0.0005$. (*B*) Advanced cell biology (24-hour quiz access periods). Solid line: Regression line for quiz access time versus quiz grade for all quizzes completed in the course (individual data points not shown); $N = 615$, $R^2 = 1.7\%$, $p = 0.001$. Dashed line: Regression line for average quiz score versus average access time for each student (•). $N = 90$, $R^2 = 7.3\%$, $p = 0.01$.

correlated with quiz access time (Fig. 1). Students taking quizzes later in the access period were more likely to achieve lower scores than students taking quizzes early. This held true both in a sophomore level introductory biology course with a 72-hour access window, and an upper-division (junior and senior) advanced cell biology course with a 24-hour access window. Average quiz grades dropped by about 10–15% over the course of the access period in both instances. These results were somewhat surprising, as we hypothesized that for any one quiz, scores would increase over time as students shared information about quiz content with their classmates. However, as scores instead decreased over time, our data suggest that widespread cheating on the online quizzes does not occur. Instead, the drop in scores over time may be due to the dynamics of the student population, as more poorly prepared students waited until later in the assignment access period to complete online quizzes.

To determine if high-achieving students were indeed more likely to complete the online quiz earlier in the access period than struggling students, students' average quiz access times were compared with their final course grades. For both courses, there was a statistically significant negative correlation between students' average quiz access times and how they ultimately performed in the course (Fig. 2). The 10% of students who had the earliest average quiz completion times had an average course grade of 3.23 (on a 4.0 scale), while the average course grade for the 10% of students who were routinely last to complete quizzes was 1.95, a statistically significant difference (*t*-test, $N = 20$, $p < 0.0005$). It thus appears that students who study course material earlier, and consequently take the quizzes earlier, are more likely to achieve a high grade in the course. This may reflect some connection between early, proactive engagement with course material and ultimate success in the course.

To analyze further how well online quizzes represented student achievement in the biology courses, we compared student's average quiz score percentile rank with their percentile rank by the end of the course. Student's achievement in quizzes positively correlated to overall course achievement, with a nearly 1:1 correspon-

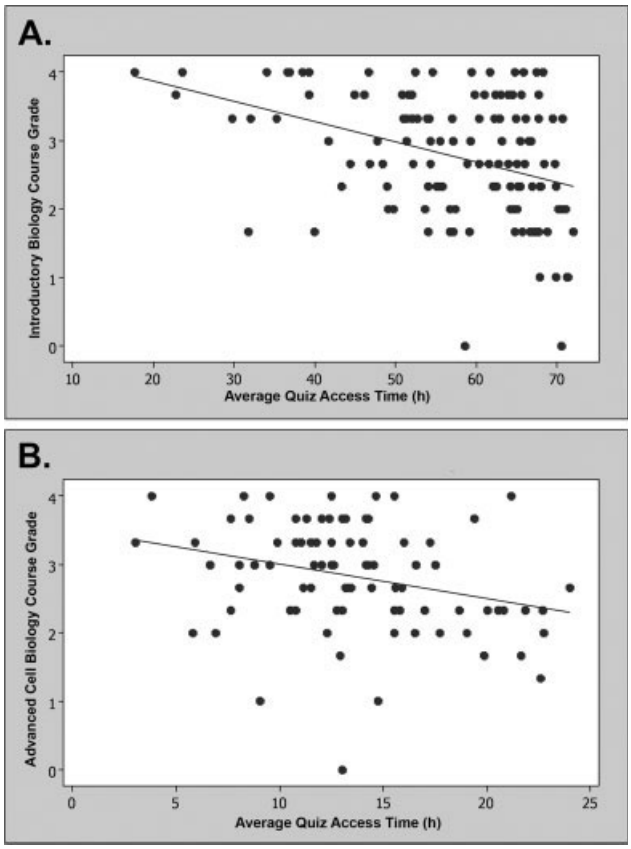

FIG. 2. **Correlation between average quiz access time and course grade.** Each student's course grade (on a 4.0 scale) was plotted as a function of their average quiz access time. (*A*) Introductory biology (72-hour quiz access periods); $N = 125$. Equation of regression line: Course grade = (−0.03) Ave. Quiz Time + 4.45; $R^2 = 14.7$ %, $p < 0.0005$. (*B*) Advanced cell biology (24-hour quiz access periods); $N = 83$. Equation of regression line: Course grade = (−0.05) Ave. Quiz Time + 3.51; $R^2 = 8.4\%$, $p = 0.008$.

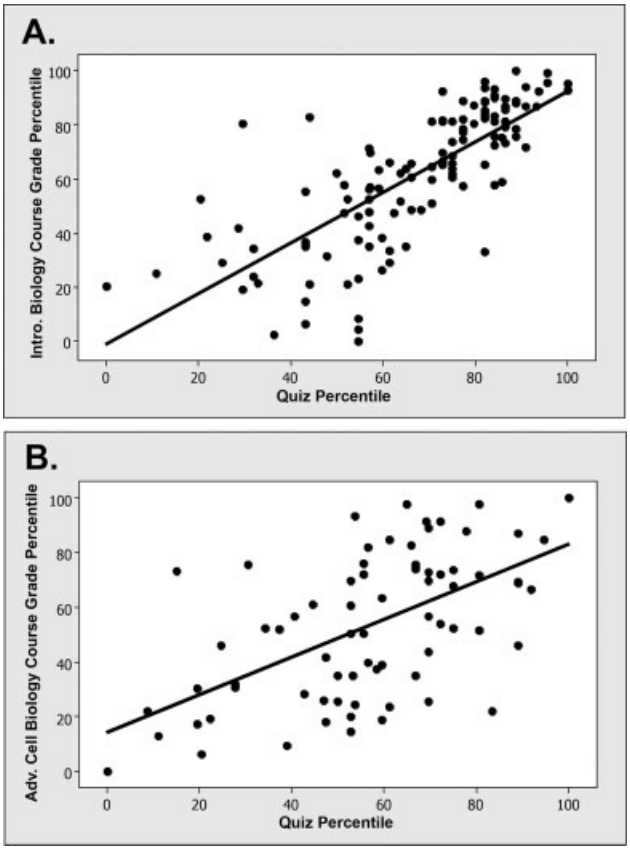

FIG. 3. **Correlation between quiz and course performance.** Each student's course percentile rank (with quiz scores removed) was compared with their quiz percentile rank. (*A*) Introductory biology; $N = 119$. Equation of regression line: Grade-percentile = (0.94) Quiz-Percentile – 1.22; $R^2 = 56.4$ %, $p < 0.0005$. (*B*) Advanced cell biology; $N = 73$. Equation of regression line: Grade-percentile = (0.69) Quiz-Percentile + 14.3; $R^2 = 32.7$ %, $p < 0.0005$.

dence between quiz and course performance (Fig. 3). The regression line slope is nearly 1.0 for introductory biology and ~0.7 for advanced cell biology, suggesting that student quiz grades were similar to their achievement in other course components (online quizzes represent about 10% of the course grade in both courses, with the other 90% determined by a combination of written work or homework and in-class exams). For this analysis, this 10% quiz-score contribution was removed from each student's grade, although results are similar if this correction is not performed. Regression line slopes much larger than 1.0 (much higher course than quiz grades) could suggest that quizzes were too difficult in relation to other course elements, while slopes much smaller than 1.0 (much higher quiz than course grades) might be indicative of either relatively easy quizzes or widespread academic dishonesty.

To further cross-check if online quizzes accurately gauged student competence in course material, when compared with in-class testing, we compared online quiz averages for advanced cell biology with in-class quiz averages for the same course offered 1 year earlier and taught by the same instructor (Table I). The in-class quizzes were identical in length and scope as the online quizzes (10 questions and a 20-min quiz period), although actual questions were different. There were no statistically significant differences in the scores between quizzes administered during lecture and those administered online ($p = 0.320$).

TABLE I
Comparison of in-class and online quiz performance in advanced cell biology

Year	Quiz type	No. of students	Ave. quiz score[a]	Std. dev.
2006	In-class	98	6.91	1.23
2007	Online	90	7.09	1.29

[a] Difference between 2006 and 2007 scores not statistically significant (ANOVA, $p = 0.320$).

As part of our study examining the online quiz-taking behavior of these large lecture biology courses, we tracked what times of day students accessed quizzes. Not surprisingly, fewer students took the quizzes very late at night; almost no quizzes were taken between 3:30 and 5:30 a.m. The largest block of students took the quiz in the last hour before it was due, whether the quiz access closing time was 3 p.m. (for introductory biology) or 8 a.m. (for advanced cell biology) (Fig. 4). Notwithstanding the last-minute rush, students appeared to prefer late afternoon or evening hours. Students in advanced cell biology were most likely to take the quiz between 8 p.m. and midnight (~17% of the access time), with 38% of the 615 individual quizzes taken throughout the

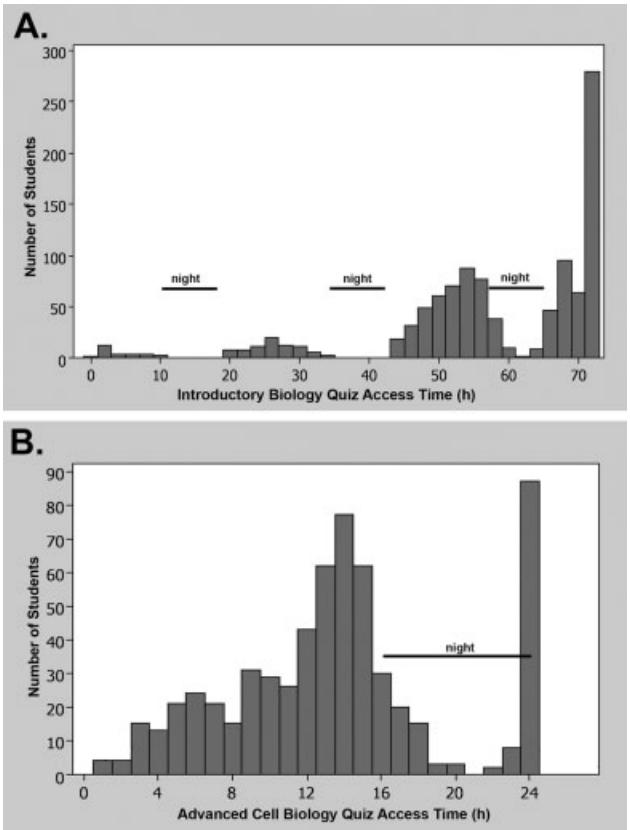

FIG. 4. **Time of quiz access across course population.** Night = 12 midnight – 8 a.m. (*A*) Introductory biology (72-hour quiz access period). (*B*) Advanced cell biology (24-hour quiz access period).

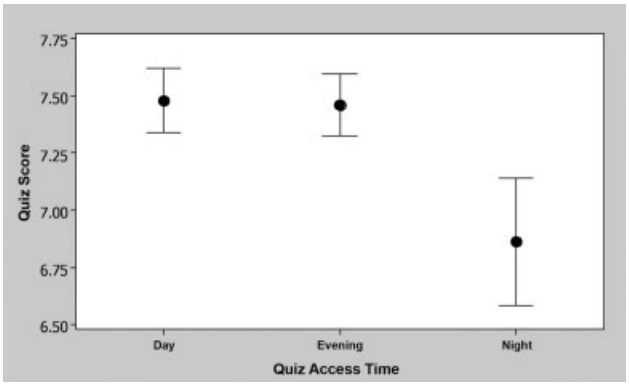

FIG. 5. **Influence of quiz access time on quiz score.** Student access times for Introductory and Advanced Cell Biology courses were scored as Day (8 a.m. – 4 p.m., $N = 736$), Evening (4 p.m. – midnight, $N = 699$), and Night (midnight – 8 a.m., $N = 216$). Average quiz scores were significantly lower for quizzes taken at night (Ave. score = 6.86) than during the day (Ave score = 7.48) or evening (Ave score = 7.46) hours (ANOVA with Tukey's *post-hoc* correction for comparison of multiple means, $p < 0.0005$).

semester accessed during this time period. Because the quiz access time for the advanced course was only 24 hours, it is possible that a different quiz end time (*e.g.* 12 noon) might give different results, both in terms of when the majority of students might choose to take quizzes, and observed trends of student quiz performance over time. Additional experiments, varying the quiz end times in future courses utilizing 24-hour quiz access periods, will be needed to determine the robustness of this result.

In introductory biology, quiz access was more homogeneously spread through the daytime hours, with activity generally peaking between 4 and 8 p.m., again with the exception of the large activity peak in the hours leading up to the 3 p.m. quiz access deadline. Although only 216 of 1,651 quizzes (13%) were taken late at night, scores for quizzes taken from midnight to 8 a.m. were significantly lower than for quizzes taken during other times of the day (Fig. 5). While there was no difference in average scores for quizzes taken during daytime (8 a.m. to 4 p.m.) or evening (4 p.m. to midnight), scores for quizzes at night were about 0.6 points lower. There are at least two possible explanations for this phenomenon. One, students who are night-owls by nature may tend to do worse in courses overall because they have difficulties engaging in courses taught during daytime hours. Two, students who spend many hours working, have time consuming non-academic responsibilities (*e.g.* families) or are taking very large course-loads may be forced into completing online assignments late at night. For these students, fatigue may play a role in their quiz performance. Over 100 years of investigation on forced wakefulness and human cognitive performance clearly indicate that there is a direct relationship between lack of sleep and poor performance on cognitive tasks such as calculation and memory recall [16].

To determine if students found quizzes helpful, students had an opportunity to write open responses regarding the use of online quizzes in the course. Even though average quiz scores were similar and in fact were slightly higher for the introductory course (7.1 for advanced cell biology (Table I) and 7.5 for introductory biology), two-thirds of responses regarding the use of quizzes in the advanced course were positive (Table II), while three-fourths of responses in the introductory course were negative (Table III). Both courses had a fair number of respondents that felt that the online quiz portion of the course was too difficult. In introductory biology, however, they were more likely to characterize the difficulty level of online quizzes as "unfair," although the quiz average was almost identical to the final course average of 75%.

TABLE II
Open responses to Quiz Satisfaction Survey for advanced cell biology

Quiz Satisfaction Survey response category: Adv. cell biology	No. of responses[a]
Forces student to stay current on course material	20
Helpful to learn the material and prepare well for exams	40
Convenient: The freedom of choosing when to take the quiz	3
Too difficult or stressful to take quizzes online	25
Inconvenient: Hard to remember to take quizzes outside of class time	5
Online examinations provide students with opportunity to cheat	1

[a] Eighty-six survey respondents, with several respondents providing comments in multiple categories. Ninety-four total comments; 63 (67%) positive, 31 (33%) negative.

DISCUSSION

Weekly online quizzes can be useful in helping students stay current on course material and provide feedback on their understanding of biological concepts. However, unsupervised online assignments may also invite academic dishonesty in highly competitive grading environments. To better understand the dynamics of online student test taking, we examined test-taking patterns and outcomes of weekly online quizzes in two large undergraduate biology lecture courses.

TABLE III
Open responses to Quiz Satisfaction Survey for introductory biology

Quiz Satisfaction Survey response category: Introductory biology	No. of responses[a]
Helpful to learn the material and prepare well for exams	20
Convenient: The freedom of choosing when to take the quiz	13
Not helpful to learning, or neutral (not helpful or harmful)	33
Quizzes unfair or too difficult	39
Time constraint too stressful or unfair	14
Inconvenient: Hard to remember to take quizzes outside of class time	11

[a] One hundred and seventeen survey respondents, with several respondents providing comments in multiple categories. One hundred and thirty total responses; 97 (75%) neutral or negative, 33 (25%) positive.

Weekly paper-based quizzes are cumbersome to administer in large lecture courses. Even short (20-min) quizzes use up nearly 20% of the available classroom instructional time in a typical three-unit course. Additionally, Family Educational Rights and Privacy Act regulations prohibit instructors from returning student work in public bins. To alleviate these problems associated with in-class quizzing, we switched to online administration of quizzes via a CMS in two large lecture biology courses. Students accessed quizzes using their student ID and a unique password, submitted their work electronically, and also retrieved their quiz results electronically once graded.

We were concerned that outsourcing quizzes to an electronic system where students were unsupervised during testing would lead to cheating. Numerous studies on cheating in college courses provide widely varying estimates on the prevalence of academic dishonesty (which can vary from as little as 3% to as high as 95%), but clearly cheating occurs on all kinds of academic work, from homework and term papers to in-class examinations [17]. However, ensuring that an enrolled student personally takes an online exam without some form of unauthorized assistance requires extraordinary measures, such mounting cameras on computers, calling students regularly to gauge their understanding of material, or requiring students to take the exam in proctored exam spaces [13, 18, 19].

Because such solutions were unworkable for the two lecture courses in the study (neither course had teaching assistants [TAs]), we used the tactics advocated by Grijalva *et al.* [14] and Olt [20] to design online exams in such a way that cheating is discouraged. This can be accomplished by allowing students to work together, limiting time to complete exams, or making quizzes "open book" [14]. Other strategies to discourage unauthorized help include individualized access to quizzes, rotating question banks, completion time constraints, and individualized assignments [20]. Asking questions that require mastery of a concept rather than simple recall can also discourage cheating [20] because answers to higher-level questions cannot be found verbatim in course material.

We used a combination of these measures to ensure the integrity of the quiz process. Quizzes represented only a small portion of the course grade ($\sim$10% total, with each quiz accounting for $\sim$1% of the overall grade). Students accessed quizzes individually using their own log-in and password. We limited the time to answer 10 multiple-choice and short-answer questions to 20 min, which would require students to study material ahead of time rather than trying to find answers during the quiz in course materials or by surfing the internet. We also set up the CMS so that unique quizzes were generated for each student from a question bank. On multiple-choice items, the order of the answer choices was scrambled by the CMS each time a quiz was generated. Finally, we included 30% higher-order reasoning questions that tested student understanding, rather than simple recall, of course concepts.

We found that it was unlikely that more than a few students found ways to cheat on quizzes set up in this manner. Rather than quiz scores increasing over time as might be expected if information about quizzes was being circulated among students, quiz grades systematically declined over the quiz access period in both introductory and upper-division biology courses. This suggested instead that students who were successful in other areas of the course, as measured by final course grade, were more likely to complete quizzes early, while students who were more poorly prepared took them at the last minute. Information leaks regarding quiz content by students attempting to cheat did not appear to play a role in the distribution of quiz scores.

Not surprisingly, quiz performance was also related to the time of day in which the assignment was completed. Although some students enjoyed the freedom of choosing when to complete quizzes (Tables II and III), students who took quizzes after midnight were less likely to do well on them. The effect, although statistically significant, was relatively small (about 6%). Given that online quizzes represented $\sim$10% of the final grade in the courses studied, taking quizzes late at night would result in less than a 1% grade difference in the final grade calculation. However, in situations where online assignments represent a greater proportion of the course grade, this effect could make a significant difference in student performance.

Including reasoning or calculation question on the quizzes, which required students to demonstrate understanding of biological concepts, appeared to help prevent students from cheating on the online quizzes. However, it also contributed to the perception that the time constraints placed on completion of the quiz were too stressful or unfair. This was particularly true for freshmen and sophomores in the introductory course. Lower-division students generally commented that questions that required them to reason through a problem or to calculate a solution should not be placed on quizzes that were taken on line in the absence of an instructor, because both access to the instructor for clarification and ample time was needed to make such questions fair. Lower-division students were also more likely to perceive online quizzes as stressful because of the time constraint, having to remember outside of class to take the quiz, and possible internet connection difficulties. Junior and senior students, conversely, were more likely to see even difficult quizzes as fair and useful in preparing for similarly structured in-class exams.

There is some evidence that online learning my not work as well for freshmen as for upper classmen. Riffell and Sibley note that in a hybrid course, online assignments had greater attendance than passive lectures that covered the same material. However, the hybrid nature of the course resulted in significantly decreased attendance in interactive discussion sessions by freshmen, even as attendance rates of upper classmen in the same learning environment remained unchanged from a traditionally structured course [4]. This suggests that upper classmen may benefit more for hybrid learning environments than lower-division students, particularly freshmen. This appeared to be the case in our study as well; lower-division students were much less open to online assess-

ment components that counted, even if only nominally, toward their final grade. Instructors should therefore proceed with caution in implementing online assessment to ensure that the online course component is perceived as helpful to learning.

CONCLUSION

As long as some reasonable safeguards are put in place to protect the online quiz process, and the incentives to cheat are relatively low, academic dishonesty does not appear to play a role in skewing student scores in online assignments. Online testing may work better in upper-division courses, and for students who prefer to complete online assignments during daytime or evening hours.

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