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# Do Open-Book Exams Impede Long-Term Learning in Introductory Biology Courses?

By Randy Moore and Philip A. Jensen
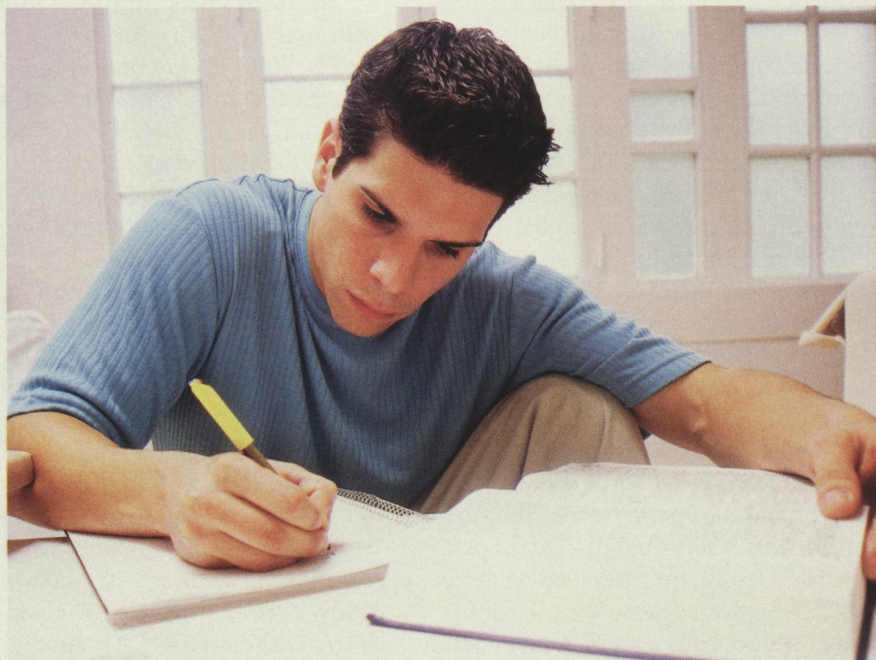
*Students in an introductory biology course who were given open-book exams during the semester earned significantly higher grades on these exams, but significantly lower grades on the closed-book final exam, than students who took in-class, closed-book exams throughout the semester. Exam format was also associated with changes in academic behavior; students who had upcoming open-book exams attended fewer lectures and help sessions and submitted fewer extra-credit assignments than students who had upcoming closed-book exams. These results suggest that open-book exams diminish long-term learning and promote academic behaviors that typify lower levels of academic achievement.*

Although academic performance is influenced by many different factors, most science instructors know the academic behaviors associated with success in introductory science courses. Indeed, the highest grades are usually earned by students who come to class regularly, participate in course-related activities (e.g., help sessions), and take advantage of opportunities to raise their grades (e.g., extra-credit assignments). These behaviors are conscious choices (e.g., students *choose* to come to class), and these choices usually have important consequences.

We've often wondered if our course policies affect students' academic behaviors. An example of such a policy involves exams. Students often ask if we will give open-book exams, usually claiming that they would do better and learn more on such exams. Some students have even claimed that the in-class, closed-book exams that typify most introductory science courses are sometimes discriminatory because of students' different learning styles. We decided to test these claims.

In this study we examine how open-book exams affect students' grades, academic behaviors, and long-term learning in an introductory biology course. We wanted to answer several questions: Do students earn higher grades on open-book exams than on closed-book exams? If so, how much higher are their grades? Do open-book exams promote long-term learning, or do students merely look up answers without understanding the information or its context? And finally, what grades do students earn on closed-book final exams that cover the same material on which they were tested earlier with open-book exams? That is, do open-book exams impede long-term learning?

## Methods

### Site of the study and its students

This study included 351 students enrolled in a traditional introductory mixed-majors biology course offered during 2005–2006 at a large, research university in the Midwest. These students had an average ACT composite score of 19.8, an average high school rank of 57%, an average age of 19, and a gender distribution of 49% female and 51% male. We excluded students whose records did not include high school GPAs or graduation percentiles, as well as students who failed the course because of academic misconduct. All sections of the course were taught by the same instructor in the same classroom with the same syllabus, textbook, grading criteria, and pedagogical approaches. All students in the course were also enrolled in a separate lab course taught by teaching assistants.

### Exams in control and experimental sections of the course

The course included three equally spaced lecture exams and a comprehensive final.

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All lecture exams included 40–50 multiple-choice questions that tested basic recall of factual information and synthesis of information, and were identical in the control and experimental sections.

In the control sections ($N = 172$), all exams were in-class, closed-book exams. Students had 75 minutes to complete each exam, and were not allowed to use any notes or books during the exams. In the experimental sections ($N = 179$), Exam 1 was an in-class, closed-book exam (i.e., like that of the control section). Exams 2 and 3 in the experimental section were open-book exams in which students could use any written or printed materials they brought to class. Answers to questions on each exam were posted on a course-related bulletin board within one to two days after each exam. The final exam in both the control and experimental sections was a comprehensive, closed-book, in-class exam that comprised 70 questions closely related to those on earlier exams.

### Students' attitudes and expectations

At the beginning of the first day of classes, we distributed a survey that included the statements shown in Table 1. Students' responses were anonymous and were not tallied until the semester was over and grades were submitted.

### Attendance, help sessions, and extra-credit assignments

On the first day of class we stressed the importance of class attendance by showing students a graph of how class attendance is correlated with course grades ($r$ [1,588] = 0.74). This graph was also included in the course syllabus and posted on the course bulletin board. Attendance was recorded at every lecture with short in-class writing assignments, but students received no points for coming to class.

Before each exam there was a help session for students with questions about course-related topics. The dates, times, and locations of the help sessions were announced on the first day of class and included in the syllabus. Attendance, which was recorded at each help session, was optional. Leaders of the help sessions only answered specific questions; they did not present lectures about course material or provide hints about the exam. All exams were prepared before the help sessions to ensure that questions asked during the help sessions did not influence the composition of the exams.

Students could earn one-third of the points they missed on lecture exams by writing one-page essays discussing the correct answers to questions they missed on the exams. Students had to write responses to all of the questions they missed to receive any credit, and had at least four weeks to submit each extra-credit assignment. Points gained by these assignments were not included in the analyses of grades in this study.

## Results
### Students in the control and experimental sections

We could find no significant differences in the demographic traits or survey responses of students in the control and experimental sections. For example, there were no significant differences in these sections' average ACT scores, high school graduation rankings, or first-day-of-class responses to the survey questions (Table 1). Similarly, there were no significant differences in grades in lab or on Exam 1 (which was the same in-class, closed-book exam in both sections; Table 2). These results suggest that there were no significant *a priori* differences among the populations of students comprising the different sections that would account for the other differences noted in their academic performances and behaviors.

Students' responses to the survey given on the first day of class are listed in Table 1; the responses of students in the control and experimental sections were similar.

### Attendance at help sessions
Similarly low percentages of students from each section attended the help session for Exam 1 (6.4 vs. 8.2% for the control and experimental sections, respectively; Table 2). However, the percentages of students from the control section who attended the help sessions for Exams 2 and 3 were 2.6 times (29 vs. 11%) and 1.6 times (34 vs. 22%) greater, respectively, than the percentages of students from the experimental section

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**TABLE 1**

Students' predictions on the first day of an introductory biology course.

Values in the table are the percentages of students who agreed with each statement.

| Statement | Control | Experimental |
|---|---|---|
| I will earn higher grades on open-book tests than on closed-book tests. | 89 | 88 |
| I will learn more with open-book tests than with closed-book tests. | 61 | 65 |
| I'd rather take open-book, take-home exams than closed-book, in-class exams. | 85 | 86 |
| I'd rather take open-book, in-class exams than closed book, in-class exams. | 82 | 84 |
| If I have a chance to raise my grade by doing an extra-credit assignment, I'll do it. | 91 | 94 |
| Students who attend optional help sessions usually earn higher grades on exams than students who do not attend help sessions. If there are help sessions, I'll attend. | 83 | 86 |
| If I get points for coming to class, I'll come to class more often than if I don't get points for coming to class. | 73 | 75 |
| I should get points for coming to class. | 60 | 63 |
| My grade in this course will be influenced most by | | |
| • my effort, | 76 | 81 |
| • my ability, | 17 | 12 |
| • the difficulty of the course, | 5 | 7 |
| • or luck. | 2 | 1 |

who attended the help sessions. The percentages of students who attended the help session before the final exam were similar in the control and experimental sections (31 vs. 29%, respectively).

### Submission of extra-credit assignments

Small percentages of students submitted extra-credit assignments (Table 2). The percentage of students in the control section who completed the first extra-credit assignment was 3.7 times greater than that for the experimental section (11.6 vs. 3.1%, respectively; Table 2). For the second extra-credit opportunity, 2.6 times more students in the control section completed the assignment (9.9 vs. 3.8%, respectively).

### Grades

Average grades on Exam 1 in the control and experimental sections were not significantly different. However, grades on Exams 2 and 3 were significantly higher in the experimental section than in the control section (Table 2). On the final exam, grades were significantly higher in the control section than in the experimental section. Lab grades for students in the control and experimental sections were not significantly different (76 vs. 78%). On the final exam, students in the

control and experimental sections had comparable scores on questions from topics covered by Exam 1. However, students in the experimental section scored lower on questions about topics covered by Exams 2 and 3 (i.e., the exams that were open-book exams for the experimental section, but closed-book for the control section; Table 2).

### Attendance at lectures

Students' patterns of lecture attendance during various periods of the course are shown in Table 3. Students in the control and experimental sections had similar rates of attendance until Exam 1, after which attendance in the control section exceeded that of the experimental section. Spread over the entire semester, attendance in the control section exceeded that of the experimental section.

## Discussion
### The control and experimental populations of students

Grades on Exam 1 were not significantly different in the control and experimental sections. That is, when given identical exams in identical conditions (i.e., closed book, in class), the average grades on Exam 1 did not differ significantly in the control and

experimental sections. These results are consistent with the fact that there were no significant differences in the average ACT scores, lab grades, and high school graduation percentile rankings among students in these two populations. The general trends reported here for attendance at lectures (declining throughout the semester), attendance at help sessions (increasing throughout the semester), and submission of extra-credit work (low levels of participation throughout the semester) are discussed elsewhere (Moore 2004, 2005).

### Do students' grades improve on open-book exams?

Not surprisingly, yes. Students who took Exams 2 and 3 as open-book exams (the experimental section) earned significantly higher grades on the exams than did students who took the exams as in-class, closed-book exams (the control section). Although we were surprised that the differences in grades on Exams 2 and 3 were so small (76% vs. 71% for the experimental vs. control sections, respectively for exam 2; 75% vs. 70% for Exam 3; Table 2), these results support students' predictions that they would earn higher grades on open-book exams than on in-class, closed-book exams (Table 1). Nevertheless, many students missed straightforward, factual questions that could have easily been looked up in their textbook.

### Do open-book exams promote long-term learning?

No. Students in the experimental section did significantly worse than students in the control section on the 50 questions of the final exam that were identical in the control and experimental sections. That is, students who took open-book exams and could look up answers on in-semester lecture exams missed significantly more of these same questions on the closed-book final exam, during which they could not look up the answers. Having open-book exams during the semester put these students at a significant disadvantage on the final exam. Moreover, the differential performances of students in the control and experimental sections were

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**TABLE 2**

Students' grades, submission of extra-credit work, and rates of attendance at lectures and optional help sessions in an introductory biology course.

|  | Control | Experimental |
|---|---|---|
| Help session, percentage of students attending | | |
| Exam 1 | 6.4 | 8.2 |
| Exam 2 | 29 | 11 |
| Exam 3 | 34 | 22 |
| Final | 31 | 29 |
| Extra-credit assignment, percentage of students completing | | |
| Exam 1 | 11 | 3.1 |
| Exam 2 | 9.9 | 3.8 |
| Grades on lecture exams, percentage | | |
| Exam 1 | 71 + 3 | 72 + 4 |
| Exam 2 | 71 + 3 | 76 + 4* |
| Exam 3 | 70 + 4 | 75 + 3* |
| Grades on final exam, percentage | | |
| Topics from Exam 1 | 73 + 4 | 70 + 3 |
| Topics from Exam 2 | 75 + 4 | 57 + 7* |
| Topics from Exam 3 | 74 + 3 | 61 + 6* |
| Overall | | 74 + 4 |
| 63 + 5* | | |
| Grades in lab, percentage | 76 + 3 | 78 + 4 |

*Indicates significant difference (p < 0.05).

not distributed uniformly across the final exam. Although students in both sections earned comparable grades on questions derived from topics covered by Exam 1, students in the experimental section earned lower average grades on all the other questions on the exam (Table 2). These results indicate that ==on a closed-book final exam, students in the experimental section recalled significantly less about topics that were covered on open-book exams than those covered by closed-book exams==. These results suggest that open-book exams may impede long-term learning of material covered in an introductory biology course.

## Are upcoming open-book exams associated with poor academic behaviors?

Yes. Students' grades are strongly associated with students' academic behaviors; students who earn the highest grades are usually those who attend class most, attend help sessions most, and submit extra-credit assignments (Friedman, Rodriguez, and McComb 2001; Launius 1997; Romer 1993). In this study, the behaviors that we measured (attendance at lectures and help sessions and submission of extra-credit assignments) were similar among students in the control and experimental sections up to, and including, Exam 1 (Tables 2 and 3). However, the behaviors of students in the control and experimental sections subsequently diverged: Students with upcoming open-book exams (i.e., students in the experimental section) were less likely to come to class, attend help sessions, and submit extra-credit assignments than were students with upcoming closed-book exams (i.e., students in the control section). These results ==suggest that open-book exams promote academic behaviors that are associated with diminished amounts of learning in introductory biology courses==.

Of course, not all students were affected by the differing formats of exams in the control and experimental sections. For example, many students in the experimental section continued to attend class and help sessions throughout the semester, regardless of the format of their upcoming exam. Our informal discussions with these students after the course indicated that they prepared for open-book exams in the same way that they prepared for closed-book exams. However, some students' rates of class attendance dropped significantly when the upcoming exam was an open-book exam. These students seemingly prepared relatively little, if at all, for the open-book exams, and during the exams we noticed that they spent much of their time looking up answers to even the most basic, straightforward question. In contrast, students who had prepared for the open-book exam were able to answer many questions without searching for the answer, thereby providing themselves more time to search for answers to other more challenging questions.

Virtually all students know that attending class, attending help sessions, and doing extra-credit work will probably improve their grades (Moore, 2006). Instructors know this, too; as Thompson noted, "If a student ever complains about a grade or how tough the course is, one of the first things I look at is class attendance. That usually says it all" (2002, p. B5). Nevertheless, and regardless of the type of exams used in a course, many students have behaviors that are inconsistent with academic success (Grisé and Kenney 2003). Our data indicate that course policies—specifically the format of an upcoming exam—also affect students' academic behaviors and long-term learning. These results do not support claims that students will learn more if they are given open-book exams. ∎

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### TABLE 3

**Average class attendance in control and experimental sections during various periods of an introductory biology course.**

Values in the table are percentages.

| Period of course | Control | Experimental | $t$ | $t$-probability |
|---|---|---|---|---|
| Day 1 to Exam 1 | 76.5 + 3.9* | 78.3 + 3.3* | 1.85 | 0.16 |
| Exam 1 to Exam 2 | 74.8 + 4.1* | 62.8 + 5.0* | 17.0 | <0.0001 |
| Exam 2 to Exam 3 | 71.0 + 5.2 | 60.3 + 4.8 | 9.10 | 0.003 |
| Day 1 to final exam | 74.7 + 3.7 | 66.2 + 7.5 | -6.09 | <0.0001 |

\* For example, the average rates of class attendance were not significantly different in the control and experimental sections in the weeks preceding Exam 1, but were significantly different in the weeks between Exams 1 and 2, and between Exams 2 and 3.