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# Promoting Academic Integrity and Student Learning in Online Biology Courses

## Comments

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## Promoting Academic Integrity and Student Learning in Online Biology Courses

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The COVID-19 pandemic has caused an abrupt shift in biology courses, with many transitioning to online instruction. This has led to an increased concern about academic integrity and cheating in online courses. Here, I draw upon the peer-reviewed literature to provide evidence-based answers to four questions concerning cheating and online biology courses: (i) What types of cheating are prevalent with the shift to online instruction? (ii) Should instructors make assessments open book and open notes? (iii) How does cheating occur in biology lab courses? (iv) Finally, what strategies can biology instructors take to uphold academic integrity with online learning? I frame these answers not only around academic integrity but on the potential impacts on student learning and discuss some strategies that may not only deter cheating but also promote greater student learning.

### INTRODUCTION

The COVID-19 pandemic has led to an abrupt increase in online instruction, including many biology courses and labs that had previously been taught in person (1). This shift to online learning has led to increased concern from instructors about how to uphold academic integrity and deter student cheating, in particular given that students are more likely to cheat in science, technology, engineering, and math (STEM) courses (2–4) and that students perceive it as easier to cheat (and more tempting to cheat) in online courses (4–6). The pandemic has also caused increases in stress and anxiety in college students (7), which can contribute to increases in academic integrity violations if students resort to cheating as a maladaptive coping strategy (8). Indeed, in the several months since the pandemic caused many courses to shift to online instruction, several retrospective works have already been published on promoting academic integrity (9–12). However, these works have focused on other fields of study, and most have not explicitly centered the discussion of promoting academic integrity alongside how any changes to a course to promote academic integrity might influence student learning. I am likewise not aware of any work to date that reviews the body of literature surrounding academic integrity specifically in online biology classes. As such, here I draw upon the peer-reviewed literature on academic

integrity as well as my experiences serving as a member of my institution's academic integrity committee (where I currently serve as co-chair) to address four questions relating to cheating in biology classes and labs. In addition to discussing these questions in the context of cheating, I frame the answers to these questions around the impact on student learning in biology courses.

### WHAT TYPES OF CHEATING ARE PREVALENT WITH THE SHIFT TO ONLINE INSTRUCTION?

Instructors should be aware of three main types of cheating for a lecture-based course; depending on how an instructor structures their course, each of these types of academic dishonesty may be more widespread with online instruction and assessments.

#### Unauthorized collaboration and sharing of answers

For both online assessments (quizzes and exams) and assignments (e.g., homework, lab reports, etc.), students may cheat by working together on questions, discussing questions with each other, or splitting up an assessment or assignment and merging their answers together (e.g., the “divide and conquer” approach where each student answers one part of an assessment on an online page like a Google Document and then all students copy from this document). Unproctored online exams can lead to more unauthorized collaboration and sharing of answers, given the relative ease of communicating with others in this situation than during a proctored, in-person exam.

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## **Contract cheating**

Contract cheating, defined as the payment of another person for work (13), has become a growing concern during the COVID-19 pandemic and the resulting online instruction. This includes the use of sites like CourseHero and Chegg, where students can submit questions from exams and obtain answers from content experts hired by the site in a relatively short amount of time (14). Online instruction has led to widespread reports of the proliferation of contract cheating (e.g., 15), since students can easily copy and paste exam questions onto contract cheating sites during an online exam. Other forms of contract cheating include hiring another student to complete an assessment or assignment or purchasing essays on sites that serve as paper mills (14).

## **Use of unauthorized resources**

Perhaps the most straightforward way to cheat is to use unauthorized resources, such as relying on notes, course recordings, other videos, and the textbook during an exam or quiz where the use of such resources is prohibited. This type of cheating is typically only found for online exams and quizzes and not for assignments, given that instructors do not tend to restrict the resources that can be used when completing an assignment.

## **SHOULD INSTRUCTORS MAKE ASSESSMENTS OPEN BOOK AND OPEN NOTES?**

Many instructors have opted to make exams and quizzes open book and open notes (hereafter referred to as OBEs, for open-book examinations) to deter cheating. However, the impacts of making such assessments open book in a biology classroom remain unclear, with studies offering sometimes contrasting findings on how OBEs influence student motivation and learning compared with closed-book exams (CBEs). Despite this, a 2016 meta-analysis of published literature comparing OBEs and CBEs across a range of fields (16) found that overall evidence supported the assertion that students may prepare less for OBEs, take longer to complete OBEs, and even do less well on OBEs in more controlled, timed environments than CBEs in similar environments. This review also found that students may overestimate the potential stress reduction from taking OBEs, with fewer students reporting reduced testing anxiety than the number of students who thought that they would have lowered test anxiety due to the format of OBEs (16). Likewise, Agarwal et al. (17) found that even if students performed equally well or better on an OBE, retention of tested concepts was worse than for students who took CBEs.

However, this body of literature about OBEs includes studies from many different fields outside of biology and the sciences. As such, it is hard to generalize from the findings,

given that student learning can be highly impacted by specific instructor, student, exam, and course attributes. There are far fewer papers that have investigated the impact of OBEs in collegiate biology courses. The few that are available are largely consistent with the themes from Durning et al. (16); Moore and Jensen (18) found that while OBEs led to higher grades on the exam in an introductory biology course, the introduction of OBEs resulted in lower scores in the closed-book final exam, suggesting lower retention of knowledge, as well as negative impacts on student behavior and motivation, such as attendance in class and use of office hours. The implementation of OBEs may have contributed to student overconfidence in their abilities in these biology courses (19). Phillips (20), on the other hand, found that the use of repeated OBEs can help promote metacognition and better study skills in biology students at a community college. Similarly, Sato et al. (21) investigated the impact of different cognitive-level questions on OBEs, speculating that some of the negative consequences on student motivation in introductory biology courses that use OBEs may be driven by the use of lower-level cognitive questions that fall on the “recall” level of Bloom’s taxonomy. These lower-level multiple-choice questions may decrease student motivation, because students may perceive that they can do well by relying on their notes and not need to synthesize concepts or use higher-order cognitive skills (21). In contrast, when comparing performance between students given OBEs and CBEs on primary literature articles in biology lab courses, Sato et al. (21) found no differences in student performance in either lower- or higher-level cognitive questions, suggesting no decrease in learning with OBEs. In addition, the data from Sato et al. (21) imply that students who are given OBEs for an entire term may change their exam preparation as they adjust to the OBEs, which may lead to benefits in student learning, though more work is needed to investigate the impact of how students adjust their studying in this scenario.

These studies indicate that instructors should proceed with caution before choosing to implement an OBE, given the possible negative impacts on student learning and retention. If instructors do choose to implement OBEs, they may wish to rely on more higher-order cognitive questions, stress this motivation to students, and rely on frequent OBE assessments to allow students time to adjust their preparation and learning strategies (21). These strategies of relying on more higher-order questions and using frequent assessments are discussed in later sections as ones that may also deter students from violating academic integrity and promote learning. In addition, while having an OBE likely reduces the amount of cheating in which students use unauthorized resources, I am not aware of any work that has investigated the impact of OBEs and the likelihood or prevalence of contract cheating or unauthorized collaborations. Future work will be needed to investigate whether the use of OBEs does lead to lower rates of other types of cheating.

## HOW DOES CHEATING OCCUR IN BIOLOGY LAB COURSES?

Very few studies have investigated cheating within biology courses, and even fewer have focused specifically on biology lab-based courses. However, the differences between a lecture-based course and a lab-based course are important, even when both are conducted online. For instance, Del Carlo and Bodner (22) reviewed the factors that might lead to cheating in a biochemistry lab course, and similarly, other researchers (23, 24) have found that students perceive differences in what is acceptable and prevalent in a lab-based course as opposed to independent research or lecture-based classes. While the other types of cheating listed above can occur in an online lab-based course, students in lab-based courses can also cheat in other ways not typically available in lecture-based courses. For example, these differences in perception can lead students to “fudge” data in lab courses, particularly if the course is more performance-based (focused on getting the correct results) than mastery-based (focused on mastering skills and concepts) (25, 26). A survey of nonmajors introductory biology lab students at one institution found that nearly two-thirds of students reported fabricating data during the term, with also alarmingly high rates of students reporting fabrication in anatomy labs (nearly 50%) and in chemistry labs (over 80% in introductory chemistry labs, and nearly 60% in organic chemistry labs) (27). While these results are a limited sample from one survey at one institution and other reports have found much more limited evidence of students fabricating data (28, 29), students fabricating data or copying data from others while conducting labs has been reported in other contexts (30), and instructors of online lab courses should be aware that the possibility of students fabricating or copying data from others is likely elevated in online lab courses.

For example, some instructors are sending kits home to students or asking students to complete experiments and gather data at home or in nearby field sites. In these circumstances, it may be easier for students to fabricate data, given the challenges of instructors verifying the results. Similarly, if instructors rely on simulations that are designed as “verification” labs, where students perform experiments to reproduce results consistent with previously learned concepts, it is likewise possible that students do not complete all of the simulations and instead gravitate towards finding the “correct” result (27). While there can be some technological solutions to prevent this, instructors can deter this type of cheating by focusing online lab-based courses on mastery of concepts and building in formative assessments that emphasize scientific thinking, both of which promote student learning (22). Similarly, avoiding such “verification” labs and “cookbook” labs with known answers and instead designing inquiry-based online labs or even online course-based undergraduate research experiences, where students are challenged to think critically about a question of unknown answer relevant to the scientific community, may further

deter fabrication or copying of data while also promoting student learning by better replicating the scientific process (31, 32). While the online format may constrain some labs, instructors may wish to consider implementing labs that challenge students to think critically about experimental design or analyze and interpret previously generated data in the context of a novel question.

## WHAT STRATEGIES CAN BIOLOGY INSTRUCTORS TAKE TO UPHOLD ACADEMIC INTEGRITY WITH ONLINE LEARNING?

### Frame assessments as part of the learning process

Students who cheat are often driven by achievement goals, and guiding students into thinking positively about assessments and their role in mastering the concepts (and the importance of gaining feedback and practice) can therefore reduce the likelihood of cheating (33, 34). Similarly, instructors can promote a growth mindset, or the belief that students can improve and grow in their mastery of material (35); such focus on self-improvement has been shown to decrease student cheating (36). Promoting growth mindsets in students has further been shown to lead to decreased achievement gaps (35) and increased performance in biology courses (37).

### Use frequent, low-stakes assessments

There have been calls for instructors to use more frequent, low-stakes assessments to discourage cheating with online instruction during the pandemic (11). These calls are grounded in multiple studies that have found that students are less likely to cheat in lower-stakes assessments than in higher-stakes assessments (38–40), and that such frequent, low-stakes assessments can also result in less student stress than high-stakes assessments (41). In addition to deterring cheating, more frequent low-stakes assessments have been shown to lead to increased student learning in biology classes, particularly when combined with highly structured active learning courses, and decreased achievement gaps between students historically underrepresented in the sciences and those who are not historically underrepresented (42–44).

### Structure assessments carefully

There are several ways that instructors can structure assessments to deter cheating. First, instructors can use higher-order cognitive questions on assessments. Several papers have suggested that using higher-order cognitive questions on assessments that move past the recall level of Bloom’s taxonomy can deter cheating by making it harder to look up the answers to such questions online (9, 11, 45). Instructors, however, should be careful to scaffold their classes to promote development of these higher-order

cognitive skills in students, which also carries benefits for student learning. A range of studies have demonstrated that reducing emphasis on memorization and instead challenging students with inquiry-based approaches and higher-order activities and assessments lead to better student performance on both higher- and lower-level cognitive questions (46). In contrast, if a course is taught only with low-level questions (focused on recalling and comprehending facts), these skills do not easily translate to higher-level cognitive skills such as problem-solving or critical thinking (47, 48). Similarly, biology courses with high levels of active learning that usually inherently feature higher-order, inquiry-based questions lead to improved performance and student attitudes about science than traditional, lecture-based models (43, 49–53) and can also reduce the achievement gap between students from disadvantaged and those from non-disadvantaged backgrounds (53, 54).

Second, instructors can carefully consider the timing of exams. There have been several calls to use short, synchronous exams to deter cheating by limiting the chances of questions and answers spreading between students and providing less time for students to collaborate or receive answers from contract cheating sites (9, 55). However, there have been relatively few studies examining the impact of time on assessments. Interestingly, Metz (56) found no evidence of widespread passing of questions or answers on online quizzes in both an upper-division cell biology course and an introductory biology course when students were allowed to take a short, 20-minute quiz asynchronously within a larger window. This study also found that students who took quizzes between midnight and 8 a.m. did worse than students who did not take the quiz late at night and that weaker students tended to take the quiz later in the provided window, leading to lower scores (56). These results are consistent with a limited number of studies of student performance in other fields (57, 58); however, most of these studies also relied on other strategies to deter cheating (randomized questions from a bank, online software, etc.), and there have been no studies that I am aware of investigating the timing of exams on the rates of cheating or the impact on student performance in biology courses since the pandemic began. Despite the lack of clear evidence regarding the timing of exams, the results from Metz (56) suggest that instructors should be aware of student technical and scheduling limitations and time zone differences and thus provide flexibility for those students. In particular, instructors may wish to give students in different time zones the opportunity to take an assessment at a reasonable time to not disadvantage certain students.

Instructors can also consider implementing alternate means of assessment, such as two-stage exams that allow group collaboration in the second part. Such two-stage exams have been shown to promote deeper learning and increased retention in biology classes (59, 60). While there has been no work that I am aware of that examines the influence of two-stage exams on student cheating, it is

possible that students will cheat less on such assessments, knowing they will be granted the chance to collaborate with their peers. Instructors can also consider other alternate forms of assessment that may deter cheating, such as oral presentations and exams, if logistically practical and aligned with the course's learning objectives.

### **Be explicit about academic integrity**

While (unsurprisingly) the most important factor in determining whether a student cheats or not is the student's "moral anchor," Spear and Miller (61) found that neither interventions based on moral appeals nor those based on fear appeals (i.e., the idea that instructors "scare" students into not cheating by listing severe sanctions) led to a significant reduction in the likelihood of students cheating. However, explicitly discussing cheating and the importance of academic integrity can help deter academic integrity violations (62). Instructors should therefore consider explicitly acknowledging and discussing these issues and adding academic integrity pledges to assessments to remind students of these expectations. In addition, instructors should be explicit about what constitutes cheating. For example, students may be unaware of the different forms of plagiarism, and it may be beneficial for instructors to cover what constitutes plagiarism and cheating on lab reports and other writing assignments. Interventions that explicitly discussed these different types of plagiarism in a biology lab course led to marked drops in plagiarism (63), and it is likely that such interventions would be effective for writing assignments in lecture-based biology classes as well.

### **Be cognizant of the impact of online proctoring**

Online proctoring software has become increasingly popular during the pandemic; such software can deter cheating by locking down browsers, providing video and audio recordings of students, conducting ID checks, and more (64, 65). In addition, there have also been some studies that indicate that there is higher student learning in online courses using proctored assessments than those using unproctored assessments, though the reasons for this remain unclear (66, 67). Although such technology offers powerful new tools to deter and prevent cheating, instructors should be aware of the potential negative impact of using such tools. First, many students may not have access to a webcam or a private, quiet space, and any online proctoring that requires a webcam or recording may disadvantage such students. Similarly, bandwidth issues and limited technological access may prevent some students from using such software. Instructors should also be aware that such online proctoring may lead to increases in student anxiety and lowered student performance (68, 69), and the use of such software may raise concerns about privacy and security. As such, if instructors do use such software, it may be helpful to explain the workflow in advance, provide practice runs

with the software, allow for alternatives for students who may not be able to successfully use this software, and take steps to decrease student stress and anxiety (70).

## CONCLUSION

Despite the renewed concerns about cheating, it is important to remember that, as instructors, our primary goal is to focus on promoting student learning and supporting students. Any changes that we make to our curriculum and courses should always be made with student learning in mind, and steps that prevent or deter cheating but damage student learning are counterproductive. In addition, given the increases in student stress and anxiety during the pandemic, instructors should couple these approaches with evidence-based strategies to reduce student stress and anxiety (70). I hope that this guide provides useful insight into promoting academic integrity in online biology courses during the COVID-19 pandemic.

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