Aspects of online college science courses that alleviate and exacerbate undergraduate depression

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Abstract

Depression is a top mental health concern among college students, yet there is a lack of research exploring how online college science courses can exacerbate or alleviate their depression. We surveyed 2,175 undergraduates at a large research-intensive institution about the severity of their depression in large-enrollment online science courses. The survey also explored aspects of online science courses that exacerbate or alleviate depression and we used regression analyses to assess whether demographics predicted responses. Over 50% of undergraduates reported experiencing depression and LGBTQ+ students, financially unstable students, and lower division students were more likely to experience severe rather than mild depression compared to their counterparts. Students reported difficulty building relationships and struggling to perform well online as aspects of online science courses that exacerbated their depression and the flexible nature of online courses and caring instructors as aspects of online courses that alleviated their depression. This study provides insight into how instructors can create more inclusive online learning environments for students with depression.

Introduction

At least a quarter of undergraduates are estimated to experience depression, making it one of the most common mental health concerns among college students [1]. Depression, defined as consistent feelings of unhappiness, hopelessness, and a loss of motivation or interest in actions that an individual previously enjoyed [2], has been correlated with decreased social integration [3], poor academic performance [4–6], and increased attrition among undergraduates [7, 8]. As a result, colleges and universities are increasingly recognizing the need to improve undergraduate mental health, specifically the awareness of mental illness and access to resources [9–12]. While the majority of efforts have focused on increasing student access to campus mental health services [10, 11], an emerging approach is to identify aspects of education that can exacerbate students’ depression in an effort to change educational environments to be more
inclusive of students with depression and/or help students with depression cope with such stressors [13–15].

Science courses in particular may present challenges for individuals with depression. Reports of chilly, unwelcoming, and competitive science course environments that are considered 'neutral' or devoid of social influence [16–18] are predicted to exacerbate students’ depressive symptoms [14, 19–22]. However, no studies have examined the frequency and severity of depression specifically among science students. Further, depression is known to affect groups that are traditionally underrepresented or underserved in science including women [23], first-generation college students [24], LGBTQ+ individuals [25], students from low socioeconomic backgrounds [25], and students with disabilities [26, 27]. Notably, students report that depression negatively affects their abilities to learn science, namely by hindering cognitive functions such as attention and time management, language skills, executive functions, and problem solving [28, 29]. As such, understanding what specific aspects of college science courses affect depression, whether such aspects disproportionately affect depression among individuals who identify within marginalized groups, and how to potentially alleviate depressive symptoms may be effective steps toward improving student performance and establishing a more diverse and inclusive scientific community.

Online education has become a common mode for delivering undergraduate science courses to students at scale. Prior to 2020, institutions of higher education increasingly adopted online courses, including science courses [30–32]. In fact, the proportion of undergraduate students taking online courses quadrupled between 2000 and 2012 [33]. In 2020, the COVID-19 pandemic further accelerated the adoption of online science education by colleges and universities. The transition to online learning impacted students around the world [34–37]. In fall 2020, 75% of U.S. institutions delivered courses either completely or partially online [38] and as of fall 2021 many U.S. institutions were continuing some degree of online coursework [39]. Notably, over 500 U.S. universities now offer solely online bachelor’s degrees, many of which are within the sciences [40].

Despite the ubiquity of online science courses and the high percentage of students struggling with depression, there is a lack of research examining how online science learning environments affect depression. As such, our research group recently conducted an in-depth exploratory interview study with 24 undergraduates with depression who were enrolled in online college science courses at an R1 institution [29]. The interviews probed what specific aspects of online education exacerbate student depression, and what aspects, if any, alleviate students’ depressive symptoms. The self-paced nature of online courses, not needing to show up to class in-person, struggling to develop relationships with other students and the instructor, and struggling to have questions answered online exacerbated student depression. Conversely, the flexibility of coursework and being able to remain anonymous in class helped alleviate students’ depression. The design of this study limited researcher bias by allowing aspects of online science courses that affected depression to emerge from student interviews, as opposed to giving students a list of aspects of online courses that affect their depression from which they could select [41]. However, the small sample size prevented our research group from assessing how common depression is among undergraduate science students and whether particular aspects of online courses are disproportionately detrimental for students with depression who identify within particular demographic groups.

Current study

Previous studies have not examined the impact of student depression on online learning or whether there are demographic differences in the challenges that students face in online
learning environments. To address these gaps in the literature and to assess how online science courses affect student depression at scale, we built upon the interview study by conducting a large-scale survey study to answer the following research questions:

1. To what extent do students in online college science courses report having depression?
2. To what extent does the severity of depression vary among undergraduates in online science courses?
3. What aspects of online science courses exacerbate students’ depression?
4. What aspects of online science courses alleviate students’ depression?

For each research question, we examined whether student demographics, including gender, race/ethnicity, LGBTQ+ status, college generation status, being financially stable, major, division in school, and GPA, predicted the respective outcome.

**Methods**

This study was conducted with an approved Institutional Review Board protocol (#13434) from Arizona State University.

To answer the research questions, we surveyed undergraduates enrolled in an in-person degree program who were completing science courses online due to the COVID-19 pandemic at a large research-intensive (R1) institution in the southwest United States where the majority of science courses for the in-person program were offered exclusively online in summer 2020, fall 2020, and spring 2021. We developed a survey based on the exploratory interview study by Mohammed and colleagues that identified aspects of online college science courses that exacerbate and alleviate depressive symptoms among undergraduates [29]. The majority of questions on the survey had been piloted during the preliminary interview study, and it was determined that students were interpreting the questions as intended [42]. After the survey was created, 13 undergraduate and graduate researchers reviewed the survey and suggested modifications using the same criteria to assess all questions (e.g., Is this question grammatically correct? Is the meaning of this question clear?) [43] and the survey was revised accordingly. A copy of the survey questions analyzed for this study is available in the S1 Appendix.

We emailed all instructors (n = 127) teaching life sciences courses at the research-intensive institution and asked if they would be willing to distribute our survey about student mental health to students in their online science courses via the online platform Qualtrics. Thirty-eight (29.9%) instructors agreed to send the survey to the students in their course(s) in exchange for extra credit or for the student to enter a drawing to win one of two $100 gift cards. We recruited from the life sciences department to maximize the number of participants in the study and the number of course experiences students could draw from; the life sciences department is the largest among the natural sciences at the institution and students in these courses were likely enrolled in multiple online science courses at once.

**Screening questions and demographics**

The survey asked students how many online college science courses they had enrolled in, which was defined for them as courses in biology, chemistry, geoscience, or physics. Students were then asked if they identify as currently or having previously struggled with depression or a depressive disorder, having never struggled with depression, or prefer not to say. We did not require students to have a formal diagnosis to identify as struggling with depression or a depressive disorder in effort to reduce bias in our study, since mental healthcare is disproportionately unavailable to Black and Latinx individuals, as well as those from low socioeconomic
backgrounds [44–46]. Only students who identified as struggling with depression or a depressive disorder were included in the analyses specific to students with depression. Below we review the survey questions and how each was analyzed as it relates to our respective research questions.

Analyses performed

For each research question, we assessed whether student demographics predicted their responses to specific questions using logistic regression analyses. All analyses were conducted in R [47]. Our predictors included gender (man/woman), race/ethnicity (white, Asian, Black, Latinx), LGBTQ+ status (yes/no), college generation status (first-generation/continuing generation), financially stable (yes/no), STEM major (yes/no), division (upper/lower), and GPA (self-reported on a 4.0 scale). Each predictor variable was determined based on literature suggesting that each may be associated with mental health [4, 13, 23–25, 48, 49]. The reasoning for how each variable was grouped is provided in the S1 Appendix. For all models, we confirmed there were no outliers and checked for multicollinearity among the predictors by assessing the variance inflation factor (VIF) values using the car package in R [50, 51]. The VIF values indicated there was no issue with multicollinearity.

RQ 1: To what extent do students in online college science courses report having depression?

To investigate the extent to which students in online college science courses report having depression, we calculated the percent of students who reported struggling with depression or a depressive disorder. Then, we used binomial logistic regression to determine to what extent students’ demographics predict whether they report having depression (Model: currently or previously struggled with depression (yes/no) ~ gender + race/ethnicity + LGBTQ+ status + college generation status + financially stable + STEM major + division + GPA).

RQ 2: What is the range in severity of depression among undergraduates in online science courses?

Students who identified as struggling with depression were asked to rate the severity of their depression, on average, in the context of online college science courses on a Likert scale including (1) little to no depression, (2) mild depression, (3) moderate depression, and (4) severe depression. We calculated the percent of students who reported each level of depression severity. Using multinomial logistic regression, we assessed to what extent students’ demographics predicted the severity of their depression. Students who identified having little to no and mild depression were combined into one category to limit our dependent variable to a total of three distinct options because we were most interested in whether there were demographic differences among students with mild depression (little to no or mild), moderate depression, and severe depression (Model: severity of depression (mild/moderate/severe) ~ gender + race/ethnicity + LGBTQ+ status + college generation status + financially stable + STEM major + division + GPA).

RQ 3 & 4: What aspects of online science courses exacerbate and alleviate student depression?

In order to investigate the specific aspects of online college science courses that affect student depression, students selected from a list of 15 aspects of online college science courses that could exacerbate their depression (e.g., deciding the pace at which I work through an online science course, struggling to have questions answered) and a list of 11 aspects of online college science courses that could alleviate their depression (e.g., easily getting to know other students in class, being able to engage in an online science course without having to be seen). These aspects of online college science courses that affect depression were developed based on the in-depth interview study of 24 undergraduates examining aspects of online science courses that affect depression [29]. Each of these aspects were organized into one of the following categories: (1) relationship building, (2) getting help or performing well, (3) fear of...
negative evaluation, or (4) flexible structure. A description of each category and the respective aspects it encompasses are included in the S1 Appendix. We calculated the percentage of students who selected each of the aspects of an online science course that exacerbated their feelings of depression and each of the aspects that alleviated their depression and tested whether there were demographic differences in which students selected each of the aspects using binomial logistic regressions (Model: selected aspect (yes/no) ~ gender + race/ethnicity + LGBTQ+ status + college generation status + financially stable + STEM major + division + GPA).

**Interpretation of analyses.** For analyses of RQ 3 & 4, we controlled for multiple hypothesis testing using a Benjamini-Hochberg (BH) p-value correction with the p.adjust function in the stats package in R [52, 53]. We considered all aspects with a BH-adjusted \( p \leq .05 \) to be significant. Whether the result of a statistical test is significant or not is continuous rather than dichotomous based on the p-value [54], but we report the results based on the standard of \( p \leq .05 \) for simplicity. We acknowledge that p-values greater than .05 can be scientifically meaningful, so we report out all results of statistical tests in the S1 Appendix for the reader’s further interpretation.

**Results**

A total of 2,175 students completed the survey and were primarily women (66.9%), white (48.4%), continuing-generation college students (58.8%), and lower division (58.1%). Forty-one percent of students reported they did not consider themselves financially stable at least part of the time and 16.8% identified as a member of the LGBTQ+ community. Student demographics are summarized in Table 1.

| Student demographic | Participants % (n) | Student demographic | Participants % (n) |
|---------------------|--------------------|---------------------|--------------------|
| **Gender**          |                    | **College generation status** |                    |
| Woman               | 66.9 (1456)        | Continuing-generation | 58.8 (1278)        |
| Man                 | 30.7 (667)         | First-generation     | 39.0 (848)         |
| Non-binary          | 1.3 (28)           | Decline to state     | 2.3 (49)           |
| Other               | 0.2 (5)            | Financially stable*  |                    |
| Decline to state    | 0.9 (19)           | Yes                 | 55.8 (1213)        |
| **Race/ethnicity**  |                    |                     |                    |
| White               | 48.4 (1053)        | Yes, but only sometimes | 28.6 (621)        |
| Hispanic, Latinx, or Spanish Origin | 21.6 (469) | Decline to state | 3.4 (73)       |
| Asian               | 15.6 (340)         | Major               |                    |
| Other, including multiracial | 4.7 (103) | A STEM major | 81.2 (1767) |
| Black or African American | 4.5 (97) | A non-STEM major | 18.7 (406)   |
| American Indian or Alaska Native | 1.8 (39)      | Decline to state | 0.1 (2)         |
| Pacific Islander    | 0.7 (15)           | Year in college     |                    |
| Decline to state    | 2.7 (59)           | 2\(^{nd}\) year or less (lower division) | 58.1 (1263) |
| LGBTQ+              |                    |                     |                    |
| No                  | 78.1 (1698)        | Decline to state     | 1.0 (21)          |
| Yes                 | 16.8 (366)         | GPA                 |                    |
| Decline to state    | 5.1 (111)          | Mean ± standard deviation | 3.5 ± 0.5 |

*Students were asked whether they considered themselves financially stable (e.g., had enough money for necessity such as groceries and rent) during the time that they have been enrolled in online college science courses.

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Finding 1: Most science undergraduates reported having depression with white students, LGBTQ+ students, women, students who are financially unstable, and students with a lower GPA being most likely to identify as having depression

Of the 2,175 participants, 54.2% (n = 1,179) reported experiencing depression. White students were more likely to report depression than Asian and Latinx students; women and LGBTQ+ students were more likely to report depression than men and non-LGBTQ+ students, respectively. Students who were financially unstable were more likely to report depression than students who were financially stable, and the lower a student’s GPA, the more likely they were to report depression. The demographic differences and respective odds ratios are summarized in Fig 1. The full result of the logistic regression and the percentage of students with depression who identify within each demographic category are reported in the S1 Appendix.

Finding 2: Women, LGBTQ+ students, continuing-generation students, financially unstable students, STEM majors, and lower division students report experiencing more severe depression

Of the 1,179 students who reported having depression, 56.4% (n = 665) described their depression as little or mild in the context of online college science courses, 33.4% (n = 394) described it as moderate, and 10.2% (n = 120) described it as severe. Women, continuing-generation students, and STEM majors were more likely to report moderate depression than little/mild depression compared to men, first-generation college students, and non-STEM majors, respectively. LGBTQ+ students were more likely to report moderate and severe depression than little or mild depression compared to non-LGBTQ+ students. Students who are financially unstable and lower division students were more likely to report severe depression than little or mild depression compared to financially stable students and upper division students, respectively. The percentage of each demographic group who experienced moderate or severe depression and the respective odds ratios of reporting moderate or severe depression are reported in Fig 2. The full result of the multinomial regression is reported in the S1 Appendix.
Finding 3: Undergraduates frequently reported that challenges building relationships in the course and aspects related to performing well were aspects of their online college science courses that exacerbated their depression.

Students most commonly selected that difficulty getting to know other students in class (61.9%), online monitored proctored testing (57.7%), at-home distractions that interfere with online science courses (54.5%), and difficulty getting to know instructors (51.5%) were aspects of online college science courses that exacerbated their depression. We identified a number of demographic differences with regard to who was more likely to select particular aspects of online college science courses that exacerbated students’ depression. White students were more likely to select an array of aspects of online courses that exacerbated their depression compared to Black students. Women were more likely than men to report that aspects of online courses related to getting help or performing well exacerbated their depression. All significant findings are reported in Table 2 (full results in the S1 Appendix).

Finding 4: Undergraduates most commonly reported the flexible course structure and having an instructor who appears to care about mental health as aspects of their online college science courses that helped alleviate their depression.

Students most commonly selected that the flexibility of doing coursework when they want (65.3%), the flexibility of doing coursework where they want (64.2%), having an instructor who appears to care about mental health (58.4%), and being able to engage in an online science course without having to be seen (48.0%) helped alleviate their depression. Women, compared to men, were consistently more likely to select particular aspects of online college science
Depression is likely on the rise among college students [55] and indeed, we found that over half of college science students have experienced depression. The COVID-19 pandemic [56–58] as well as national racial unrest and the increase of racially driven hate crimes in the United States occurring in 2020 and 2021 [59] undoubtedly contributed to the uniquely high rates of depression among science students during the spring 2021 term. However, this research highlights that while depression is common among science students, it disproportionately affects specific groups of science students including LGBTQ+ students, women, financially unstable students, and students with lower GPAs. It is important to note that while white students were more likely to report depression than their Asian and Latinx peers, it is thought that cultural stigmas surrounding depression [60–63] and inadequate access to mental healthcare [44, 45, 64] may influence the underreporting of depression among Asian and Latinx individuals. Additionally, women, LGBTQ+ students, continuing-generation students, financially unstable students, STEM majors, and lower division students experienced more severe depression during the spring 2021 term. Depression is thought to negatively impact student learning [4, 5, 65, 66], likely because it can interfere with one’s cognitive domains [29]. Therefore, the

Table 2. Aspects of online science courses that exacerbate student depression and demographic differences among who selected each aspect.

| Aspect of online college science courses that exacerbates depression | % (n) of students who selected the aspect (N = 1,176) | Demographic group who was more likely to select the aspect |
|---------------------------------------------------------------------|----------------------------------------------------|----------------------------------------------------------|
| Difficulty getting to know other students in class                 | 61.9 (728)                                         | Continuing generation Lower division                      |
| Online monitored proctored testing                                 | 57.7 (678)                                         | Women White (compared to Black)                           |
| At-home distractions that can interfere with online science courses | 54.5 (641)                                         |                                                          |
| Difficulty getting to know instructors                            | 51.4 (605)                                         | White (compared to Black)                                 |
| Difficulty getting help from other students in class               | 49.7 (584)                                         | White (compared to Black)                                 |
| Struggling to have questions answered                             | 48.6 (571)                                         | Women White (compared to Black)                           |
| Difficulty getting help from instructors                           | 47.5 (559)                                         | White (compared to Black)                                 |
| Struggling to communicate effectively with the instructor          | 46.9 (551)                                         | White (compared to Black)                                 |
| Comparing myself to other students                                | 46.0 (541)                                         | Women White (compared to Black)                           |
| Needing to navigate technology in high-pressure situations (e.g., during online exams) | 45.4 (534)                                         | Women Financially unstable                                |

Logistic regression analyses assessed the relationship between whether a student selected a particular aspect of the course that exacerbated their depression and their gender, race/ethnicity, college generation status, LGBTQ+ status, being financially stable, major, GPA, and division in school. Colors represent the broader category of each aspect: yellow = relationship building; purple = getting help or performing well; blue = fear of negative evaluation.

*Of the 1,179 students who identified as having depression, three students did not answer the question regarding the aspects of online college science courses which exacerbate their depression, so the percentages reported are out of the 1,176 students who answered the question.

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courses that alleviated their depression. All significant findings are reported in Table 3 (full results in the S1 Appendix).

Discussion

Depression is likely on the rise among college students [55] and indeed, we found that over half of college science students have experienced depression. The COVID-19 pandemic [56–58] as well as national racial unrest and the increase of racially driven hate crimes in the United States occurring in 2020 and 2021 [59] undoubtedly contributed to the uniquely high rates of depression among science students during the spring 2021 term. However, this research highlights that while depression is common among science students, it disproportionately affects specific groups of science students including LGBTQ+ students, women, financially unstable students, and students with lower GPAs. It is important to note that while white students were more likely to report depression than their Asian and Latinx peers, it is thought that cultural stigmas surrounding depression [60–63] and inadequate access to mental healthcare [44, 45, 64] may influence the underreporting of depression among Asian and Latinx individuals. Additionally, women, LGBTQ+ students, continuing-generation students, financially unstable students, STEM majors, and lower division students experienced more severe depression during the spring 2021 term. Depression is thought to negatively impact student learning [4, 5, 65, 66], likely because it can interfere with one’s cognitive domains [29]. Therefore, the
disproportionately high rates and severity of depression experienced among underserved groups in science may be partially contributing to underperformance and attrition in the sciences [67–71].

While curbing the effects of familial and societal events on students’ depression is often beyond the ability of colleges and universities, there is increasing evidence that several aspects of college itself may have an impact on student mental health. This study adds to the recent research establishing that science learning environments in particular may affect depression [13, 14, 72]. Our foundational interview study [29] provided evidence that aspects of online learning related to social interactions, getting help or performing well, being evaluated by others, and flexibility affect student depression and the data presented in this study imply that these findings can be generalized to a larger population of students.

The social aspects of online learning greatly affect students’ depression. Not getting to know other students in class was the most common aspect of online courses that students selected as exacerbating their depression and not getting to know instructors was reported by over half of participants. The lack of opportunities for both formal and informal interactions in online courses [73, 74] makes it difficult to form student-student and student-instructor relationships, which likely results in or amplifies feelings of loneliness, a common symptom of depression [13, 15, 29]. Further, the lack of student-student interactions may be particularly detrimental for students’ depression in spring 2021, given that the COVID-19 pandemic resulted in social isolation for most individuals [75–78].

In addition to the difficulty of developing relationships online, online proctored testing and at-home distractions that interfered with students’ courses were also selected by over half of students as aspects that exacerbated their depression. Proctored online testing has been found to exacerbate student anxiety [79–83] and to create challenges for students with disabilities [84, 85]. The threat of being “flagged” as cheating when carrying out routine behaviors such as looking down or even needing to step away for health reasons has been described to take a profound toll on students’ mental health, which is echoed by students in this study. Additionally,

### Table 3. Aspects of online science courses that alleviate student depression and demographic differences among who selected each aspect.

| Aspects of online college science courses that alleviate depression | % (n) of students who selected the aspect (N = 1,175)* | Demographic group who was more likely to select each aspect |
|---------------------------------------------------------------|---------------------------------------------------|----------------------------------------------------------|
| The flexibility of doing coursework when I want              | 65.3 (767)                                       | Women                                                    |
| The flexibility of doing coursework where I want             | 64.2 (754)                                       | Women                                                    |
| Having an instructor who appears to care about mental health | 58.4 (686)                                       | Women                                                    |
| Being able to engage in an online science course without having to be seen | 48.0 (564)                                       | Women                                                    |
| Being anonymous or being able to share my opinion without it being associated with my face | 45.4 (534)                                       | Women                                                    |
| Clear communication with instructors                          | 37.5 (441)                                       | Women                                                    |
| Getting questions answered                                    | 33.8 (397)                                       | Women                                                    |
| Easily getting help from instructors                          | 31.3 (368)                                       | Women                                                    |
| Easily getting help from other students in class              | 24.8 (291)                                       | Women                                                    |
| Easily getting to know other students in class                | 24.8 (291)                                       | Women                                                    |

Logistic regression analyses assessed the relationship between whether a student selected a particular aspect of the course that alleviated their depression and their gender, race/ethnicity, college generation status, LGBTQ+ status, being financially stable, major, GPA, and division in school. Colors represent the broader category of each aspect: yellow = relationship building; purple = getting help or performing well; blue = fear of negative evaluation; orange = flexible structure.

*Of the 1,179 students who identified as having depression, four students did not answer the question regarding the aspects of online college science courses that alleviate their depression, so the percentages reported are out of the 1,175 students who answered the question.

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at home distractions have been shown to increase anxiety levels of students in online courses because such distractions make it harder for students to focus and concentrate [82, 86], which may also lead to increased feelings of frustration and hopelessness related to depression.

Both aspects of flexible online instruction that were listed for students, completing coursework where students want and completing coursework when students want, emerged as the top two aspects that helped alleviate student depression. Since depressive episodes can result in fatigue as well as diminished abilities to think or concentrate, having the flexibility to engage in coursework when a student feels best likely prevents the exacerbation of depressive symptoms, such as feelings of guilt associated with not performing well in class [2, 29]. Our previous study found that not having to physically go to class can be detrimental for students with depression because it can discourage them from completing activities of daily living such as brushing one’s teeth or hair or getting dressed, but students also described that having to be physically present when experiencing a major depressive episode or losing points for being physically absent from class took a toll on their depression [29]. As such, it was difficult to discern from the interview study what the overall effect of needing to show up to class in person might have on students with depression, but this quantitative study suggests that students may see being able to complete coursework from where they want as more of an advantage for their depression than a disadvantage.

Overall, we found few notable trends with regard to the demographic differences in what aspects of online college science courses alleviated and exacerbated undergraduates’ depression. White students were more likely than Black students to report that aspects of their courses affected their depression. However, given the state of racial unrest of the United States before and during the spring 2021 term, the state of the nation and racial injustices may have been much more impactful on Black students’ depression than aspects of online learning [87–90]. Women were more likely than men to report that an array of aspects of online college science courses exacerbated and helped alleviate their depression. This may be because women often experience stereotype threat, defined as having the potential to confirm a negative stereotype about one’s group [91], in science disciplines which may threaten their mental health [92]. Additionally, women are more likely to seek help for their mental health, so may be better able to identify aspects of online courses that exacerbate or alleviate their depression [93–95].

As we strive for an inclusive science learning environment for everyone, we propose recommendations based on the data presented in this study to help instructors create more inclusive online science courses for students with depression. Students benefit from building relationships online with both peers and instructors [96–100] and our data suggest this is likely protective of students’ mental health. As such, integrating opportunities for students to interact with each other (e.g., breakout rooms, small group work, discussion board posts) and the instructor (e.g., holding virtual office hours) may be effective in helping to build such relationships and improve mental health. Additionally, monitored proctored testing was frequently reported as an aspect that negatively affected students’ depression and has also been found to exacerbate student anxiety [82]. While we acknowledge that the elimination of proctoring software may lead to an increase in academic dishonesty, we encourage instructors to consider alternative forms of evaluation. For example, replacing infrequent high-stakes testing with more frequent low-stakes evaluation may disproportionately benefit students’ mental health and consequently students with underrepresented and underserved identities [71, 101–103]. Finally, students reported that it helps to alleviate their depression when they perceive their instructor cares about mental health. Making an announcement at the beginning of the term acknowledging the importance of mental health, providing students with resources such as information about the disability resource center, and putting a clause in the syllabus about the extent
to which one values student mental health [104] are all simple steps that have the potential to positively impact student mental health.

Limitations and future directions
This study was conducted during the COVID-19 pandemic. While we asked students to report on aspects of online courses that affect their depression that were unrelated to the pandemic, it is likely that the stress and isolation associated with COVID-19 increased the number of students who identified as having depression. Further, this study was conducted at a large R1 institution in the U.S., so the results may not be generalizable across other institution types or other countries. Students self-identified as having depression and were not required to have a diagnosis of depression to take part in this study because mental healthcare is disproportionately available to more privileged groups [44–46]. However, self-report of depression has been found to be relatively accurate and appropriate in non-clinical contexts [105]. While this study identified aspects of online college science courses that students reported alleviated their depressive symptoms, future research could experimentally assess to what extent a change in a course (e.g., increasing flexibility, facilitating student-student interactions) results in a decrease of depressive symptoms among students. This would allow for more concrete recommendations about how to create more inclusive science courses for students with depression.

Supporting information
S1 Appendix. Supplementary material. All supplementary material for the manuscript including a copy of the survey and full results of regression analyses. (DOCX)
S1 Dataset. De-identified dataset. Dataset used in all data analyses. (CSV)

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References

1. American College Health Association. American College Health Association-National College Health Assessment III: Undergraduate Student Reference Group Executive Summary Fall 2020. Silver Spring, MD: American College Health Association; 2021.

2. American Psychiatric Association. Diagnostic and statistical manual of mental disorders, fifth edition. Am Psychiatr Assoc. 2013; 21. https://doi.org/10.1378/cp.13-1691 PMID: 24297138

3. Geyer EC, Fua KC, Daniel KE, Chow PI, Bonelli W, Huang Y, et al. I did OK, but did I like it? Using ecological momentary assessment to examine perceptions of social interactions associated with severity of social anxiety and depression. Behav Ther. 2018; 49: 866–880. https://doi.org/10.1016/j.beth.2018.07.009 PMID: 30316486

4. Hysenbegasi A, Hass SL, Rowland CR. The impact of depression on the academic productivity of university students. J Ment Health Policy Econ. 2005; 8: 145. PMID: 16278502

5. DeRoma VM, Leach JB, Leverett JP. The relationship between depression and college academic performance. Coll Stud J. 2009; 43: 325–335.

6. Yasin M, Dzulkifli MA. Differences in depression, anxiety and stress between low-and high-achieving students. J Sustain Sci Manag. 2011; 6: 169–178.

7. Arria AM, Caldeira KM, Vincent KB, Winick ER, Baron RA, O’Grady KE. Discontinuous college enrollment: Associations with substance use and mental health. Psychiatr Serv. 2013; 64: 165–172. https://doi.org/10.1176/appi.ps.201200106 PMID: 23474608

8. Thompson-Ebanks V. Leaving college prematurely: The experiences of nontraditional-age college students with depression. J Coll Stud Retent Res Theory Pract. 2017; 18: 474–495.

9. Mistrler BJ, Reetz DR, Krylowicz B, Barr V. The association for university and college counseling center directors annual survey. Retrieved Assoc Univ Coll Couns Cent Dir Website Httpfiles Cmcglobal Com-Monograph2012AUCCCDPublic Pdf. 2012.

10. National Council on Disability. Mental health on college campuses: Investments, accommodations needed to address student needs. 2017.

11. Center for Collegiate Mental Health. Center for Collegiate Mental Health (CCMH) 2020 Annual Report. 2020; 40.

12. Hsu JL, Goldsmith GR. Instructor Strategies to Alleviate Stress and Anxiety among College and University STEM Students. Brame C, editor. CBE—Life Sci Educ. 2021; 20: es1. https://doi.org/10.1187/cbe.20-08-0189 PMID: 33635124

13. Cooper KM, Gin LE, Barnes ME, Brownell SE. An Exploratory Study of Students with Depression in Undergraduate Research Experiences. CBE—Life Sci Educ. 2020; 19: ar19. https://doi.org/10.1187/cbe.19-11-0217 PMID: 32412838

14. Cooper KM, Gin LE, Brownell SE. Depression as a concealable stigmatized identity: what influences whether students conceal or reveal their depression in undergraduate research experiences? Int J STEM Educ. 2020; 7: 27. https://doi.org/10.1186/s40594-020-00216-5 PMID: 32550126

15. Gin LE, Wiesenthal NJ, Ferreira I, Cooper KM. PhDepression: Examining How Graduate Research and Teaching Affect Depression in Life Sciences PhD Students. CBE—Life Sci Educ. 2021; 20: ar41. https://doi.org/10.1187/cbe.21-03-0077 PMID: 34309412

16. Harding S. After the neutrality ideal: Science, politics, and* strong objectivity*. Soc Res. 1992; 567–587.

17. Rosser SV. Female friendly science: Including women in curricular content and pedagogy in science. J Gen Educ. 1993; 42: 191–220.

18. Strenta AC, Elliott R, Adair R, Matter M, Scott J. Choosing and leaving science in highly selective institutions. Res High Educ. 1994; 35: 513–547.

19. Seymour E, Hewitt NM. Talking about leaving. Westview Press, Boulder, CO; 1997.

20. Osborne J, Collins S. Pupils’ views of the role and value of the science curriculum: a focus-group study. Int J Sci Educ. 2001; 23: 441–467.
21. Armbruster P, Patel M, Johnson E, Weiss M. Active learning and student-centered pedagogy improve student attitudes and performance in introductory biology. CBE—Life Sci Educ. 2009; 8: 203–213. https://doi.org/10.1187/cbe.09-03-0025 PMID: 19723815

22. Ceci SJ, Williams WM. Sex differences in math-intensive fields. Curr Dir Psychol Sci. 2010; 19: 275–279. https://doi.org/10.1177/0963721410383241 PMID: 21152367

23. Kessler RC. Epidemiology of women and depression. J Affect Disord. 2003; 74: 5–13. https://doi.org/10.1016/S0165-0327(02)00426-3 PMID: 12646294

24. Jenkins SR, Belanger A, Connally ML, Boals A, Durón KM. First-generation undergraduate students' social support, depression, and life satisfaction. J Coll Couns. 2013; 16: 129–142.

25. Eisenberg D, Gollust SE, Golberstein E, Hefner JL. Prevalence and correlates of depression, anxiety, and suicidality among university students. Am J Orthopsychiatry. 2007; 77: 534–542. https://doi.org/10.1037/0002-9432.77.4.534 PMID: 18194033

26. Arnow BA, Hunkeler EM, Blasey CM, Lee J, Constantino MJ, Fireman B, et al. Comorbid depression, chronic pain, and disability in primary care. Psychosom Med. 2006; 68: 262–268. https://doi.org/10.1097/01.psy.0000204851.15499.fc PMID: 16554392

27. Hsieh K, Scott HM, Murthy S. Associated risk factors for depression and anxiety in adults with intellectual and developmental disabilities: Five-year follow-up. Am J Intel Dev Disabil. 2020; 125: 49–63. https://doi.org/10.1352/1944-7558-125.4.49 PMID: 31877262

28. Kecojevic A, Basch CH, Sullivan M, Davi NK. The impact of the COVID-19 epidemic on mental health of undergraduate students in New Jersey, cross-sectional study. PLoS One. 2020; 15: e0239696. https://doi.org/10.1371/journal.pone.0239696 PMID: 32997683

29. Mohammed TF, Gin LE, Wiesenthal NJ, Cooper KM. The Experiences of Undergraduates with Depression in Online Science Learning Environments. CBE—Life Sci Educ. 2022; 21: ar18. https://doi.org/10.1187/cbe.21-09-0228 PMID: 35294254

30. Allen IE, Seaman J. Changing course: Ten years of tracking online education in the United States. ERIC; 2013.

31. Varty AK. Options for online undergraduate courses in biology at American colleges and universities. CBE—Life Sci Educ, 2016; 15: ar58. https://doi.org/10.1187/cbe.16-01-0075 PMID: 27856546

32. Mead C, Supriya K, Zheng Y, Anbar AD, Collins JP, LePore P, et al. Online biology degree program broadens access for women, first-generation to college, and low-income students, but grade disparities remain. PLOS ONE. 2020; 15: e0243916. https://doi.org/10.1371/journal.pone.0243916 PMID: 33306720

33. Protopsaltis S, Baum S. Does online education live up to its promise? A look at the evidence and implications for federal policy. Cent Educ Policy Eval. 2019.

34. Chakraborty P, Mittal P, Gupta MS, Yadav S, Arora A. Opinion of students on online education during the COVID-19 pandemic. Hum Behav Emerg Technol. 2021; 3: 357–365. https://doi.org/10.1002/hbe2.240

35. Fawaz M, Samaha A. E-learning: Depression, anxiety, and stress symptomatology among Lebanese university students during COVID-19 quarantine. Nurs Forum (Auckl). 2021; 56: 52–57. https://doi.org/10.1016/j.nurfo.2021.02.006

36. Islam S, Akter R, Sikder T, Griffiths MD. Prevalence and factors associated with depression and anxiety among first-year university students in Bangladesh: a cross-sectional study. Int J Ment Health Addict. 2020; 1–14.

37. Asgari S, Trajkovic J, Rahmani M, Zhang W, Lo RC, Sciortino A. An observational study of engineering online education during the COVID-19 pandemic. PLOS ONE. 2021; 16: e0250041. https://doi.org/10.1371/journal.pone.0250041 PMID: 33857219

38. The Chronicle of Higher Education. Here’s Our List of Colleges’ Reopening Models. In: The Chronicle of Higher Education [Internet]. 28 Aug 2020 [cited 31 Aug 2021]. https://www.chronicle.com/article/heres-a-list-of-colleges-plans-for-reopening-in-the-fall/

39. Jaszchik S. Delta variant raises questions for colleges about reopening plans. In: Inside Higher Ed [Internet]. 16 Aug 2021 [cited 31 Aug 2021]. https://www.insidehighered.com/news/2021/08/16/delta-variant-raises-questions-colleges-about-reopening-plans

40. List of Accredited Online Colleges & Universities. 21 May 2021 [cited 31 Aug 2021]. https://www.onlineu.com/online-schools

41. Geer JG. Do open-ended questions measure “salient” issues? Public Opin Q. 1991; 55: 360–370.

42. Trenor J, Miller M, Gipson K. Utilization of a Think-Aloud Protocol to Cognitively Validate a Survey Instrument Identifying Social Capital Resources of Engineering Undergraduates. 2011 ASEE Annual Conference & Exposition Proceedings. Vancouver, BC: ASEE Conferences; 2011. p. 22.1656.1–22.1656.15.
43. Bowden A, Fox-Rushby JA, Nyandieka L, Wanjau J. Methods for pre-testing and piloting survey questions: illustrations from the KENQOL survey of health-related quality of life. Health Policy Plan. 2002; 17: 322–330. https://doi.org/10.1093/heapoli/17.3.322 PMID: 12135999

44. Kataoka SH, Zhang L, Wells KB. Unmet need for mental health care among US children: Variation by ethnicity and insurance status. Am J Psychiatry. 2002; 159: 1548–1555. https://doi.org/10.1176/appi.ajp.159.9.1548 PMID: 1202276

45. Howell E, McFeeters J. Children’s mental health care: Differences by race/ethnicity in urban/rural areas. J Health Care Poor Underserved. 2008; 19: 237–247. https://doi.org/10.1353/hpu.2008.0008 PMID: 18263999

46. Santiago CD, Kaltman S, Miranda J. Poverty and mental health: how do low-income adults and children fare in psychotherapy? J Clin Psychol. 2013; 69: 115–126. https://doi.org/10.1002/jclp.21951 PMID: 23280880

47. R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, 2021.

48. Barnes DM, Keyes KM, Bates LM. Racial differences in depression in the United States: how do subgroup analyses inform a paradox? Soc Psychiatry Psychiatr Epidemiol. 2013; 48: 1941–1949. https://doi.org/10.1007/s00127-013-0718-7 PMID: 23732705

49. Satinsky EN, Kimura T, Kiang MV, Abebe R, Cunningham S, Lee H, et al. Systematic review and meta-analysis of depression, anxiety, and suicidal ideation among Ph. D. students. Sci Rep. 2021; 11: 1–12. https://doi.org/10.1038/s41598-020-79139-8 PMID: 33414495

50. Fox J, Weisberg S. An R companion to applied regression. Thousand Oaks, CA: Sage publications; 2018.

51. Son C, Hegde S, Smith A, Wang X, Sasonkoy F. Effects of COVID-19 on college students’ mental health in the United States: Interview survey study. J Med Internet Res. 2020; 22: e21279. https://doi.org/10.2196/21279 PMID: 32805704

52. Ettman CK, Abdalla SM, Cohen GH, Sampson L, Vivier PM, Galea S. Prevalence of depression symptoms in US adults before and during the COVID-19 pandemic. JAMA Netw Open. 2020; 3: e2019686–e2019686. https://doi.org/10.1001/jamanetworkopen.2020.19686 PMID: 32876685

53. Kibbey MM, Fedorenko EJ, Farris SG. Anxiety, depression, and health anxiety in undergraduate students living in initial US outbreak “hotspot” during COVID-19 pandemic. Cogn Behav Ther. 2021; 50: 409–421. https://doi.org/10.1080/16506073.2020.1853805 PMID: 33433271

54. Abrams Z. The mental health impact of anti-Asian racism. Monit Psychol. https://www.Apa.Orgmonitor202107impactanti-Asian-Racism. 2021.

55. Nadeem E, Lange JM, Edge D, Fongwa M, Belin T, Miranda J. Does stigma keep poor young immigrant and US-born Black and Latina women from seeking mental health care? Psychiatr Serv. 2007; 58: 1547–1554. https://doi.org/10.1176/ps.2007.58.12.1547 PMID: 18048555

56. Interian A, Ang A, Gara MA, Link BG, Rodriguez MA, Vega WA. Stigma and depression treatment utilization among Latinos: utility of four stigma measures. Psychiatr Serv. 2010; 61: 373–379. https://doi.org/10.1176/ps.2010.61.4.373 PMID: 20362276

57. Fogel J, Ford DE. Stigma beliefs of Asian Americans with depression in an internet sample. Can J Psychiatry. 2005; 50: 470–478. https://doi.org/10.1177/0706743705000080 PMID: 16127965

58. Miville ML, Constantine MG. Cultural values, counseling stigma, and intentions to seek counseling among Asian American college women. Couns Values. 2007; 52: 2–11.

59. Augsberger A, Yeung A, Dougher M, Hahn HC. Factors influencing the underutilization of mental health services among Asian American women with a history of depression and suicide. BMC Health Serv Res. 2015; 15: 1–11. https://doi.org/10.1186/s12913-014-0652-8 PMID: 25603697

60. American College Health Association. American College Health Association-National College Health Assessment II: Undergraduate Student Reference Group Data Report Fall 2018. Silver Spring, MD: American College Health Association; 2018.
66. Humphrey EA, Wiles JR. Lessons learned through listening to biology students during a transition to online learning in the wake of the COVID-19 pandemic. Ecol Evol. 2021; 11: 3450–3458. https://doi.org/10.1002/ece3.7303 PMID: 33898001

67. Rauschenberger MM, Sweeder RD. Gender performance differences in biochemistry. Biochem Mol Biol Educ. 2010; 38: 380–384. https://doi.org/10.1002/bmb.20448 PMID: 21567866

68. Eddy SL, Brownell SE, Wenderoth MP. Gender Gaps in Achievement and Participation in Multiple Introductory Biology Classrooms. CBE—Life Sci Educ. 2014; 13: 478–492. https://doi.org/10.1187/cbe.13-10-0204 PMID: 25185231

69. Marrero ME, Gunning AM, Germain-Williams T. What is STEM education? Glob Educ Rev. 2014; 1.

70. Wright CD, Eddy SL, Wenderoth MP, Abshire E, Blankenbiller M, Brownell SE. Cognitive difficulty and format of exams predicts gender and socioeconomic gaps in exam performance of students in introductory biology courses. CBE—Life Sci Educ. 2016; 15: ar23. https://doi.org/10.1187/cbe.15-12-0246 PMID: 27252299

71. Harris RB, Mack MR, Bryant J, Theobald EJ, Freeman S. Reducing achievement gaps in undergraduate general chemistry could lift underrepresented students into a “hyperpersistent zone”. Sci Adv. 2020; 6: eaaz5687. https://doi.org/10.1126/sciadv.aaz5687 PMID: 32577510

72. Evans TM, Bira L, Gastelum JB, Weiss LT, Vanderford NL. Evidence for a mental health crisis in graduate education. Nat Biotechnol. 2018; 36: 282–284. https://doi.org/10.1038/nbt.4089 PMID: 29509732

73. Contreras-Castillo J, Favela J, Pérez-Fragoso C, Santamaría-del-Angel E. Informal interactions and their implications for online courses. Comput Educ. 2004; 42: 149–168.

74. Jaggars SS. Choosing between online and face-to-face courses: Community college student voices. Am J Distance Educ. 2014; 28: 27–38.

75. Bezerra ACV, da Silva CEM, Soares FFR, da Silva JAM. Factors associated with people’s behavior in social isolation during the COVID-19 pandemic. Cienc Saude Coletiva. 2020; 25: 2411–2421. https://doi.org/10.1590/1413-81232020256.1.10792020 PMID: 32520286

76. Pietrabissa G, Simpson SG. Psychological consequences of social isolation during COVID-19 outbreak. Front Psychol. 2020; 11: 2201. https://doi.org/10.3389/fpsyg.2020.02201 PMID: 33013572

77. Ramírez-Ortiz J, Castro-Quintero D, Lerma-Córdoba C, Yela-Ceballos F, Escobar-Córdoba F. Mental health consequences of the COVID-19 pandemic associated with social isolation. Colomb J Anestesiol. 2020; 48.

78. Kim HH, Jung JH. Social isolation and psychological distress during the COVID-19 pandemic: A cross-national analysis. The Gerontologist. 2021; 61: 103–113. https://doi.org/10.1093/geront/gnaa168 PMID: 33125065

79. Stowell JR, Bennett D. Effects of Online Testing on Student Exam Performance and Test Anxiety. J Educ Comput Res. 2010; 42: 161–171. https://doi.org/10.2190/EC.42.2.b

80. Kolski T, Weible J. Examining the Relationship between Student Test Anxiety and Webcam Based Exam Proctoring. Online J Distance Learn Adm. 2018; 21. https://www.learntechlib.org/p/188457/

81. Woldeab D, Brothen T. 21st Century assessment: Online proctoring, test anxiety, and student performance. 2019.

82. Mohammed TF, Nadile EM, Busch CA, Brister D, Brownell SE, Claiborne CT, et al. Aspects of Large-Enrollment Online College Science Courses That Exacerbate and Alleviate Student Anxiety. CBE—Life Sci Educ. 2021; 20: ar69. https://doi.org/10.1187/cbe.21-05-0132 PMID: 34808910

83. Woldeab D, Brothen T. Video Surveillance of Online Exam Proctoring: Exam Anxiety and Student Performance. 2021.

84. Gin LE, Guerrero FA, Brownell SE, Cooper KM. COVID-19 and Undergraduates with Disabilities: Challenges Resulting from the Rapid Transition to Online Course Delivery for Students with Disabilities in Undergraduate STEM at Large-Enrollment Institutions. CBE—Life Sci Educ. 2021; 20: ar96. https://doi.org/10.1187/cbe.21-02-0028 PMID: 34114885

85. Gin LE, Pais DC, Parrish KD, Brownell SE, Cooper KM. New online accommodations are not enough: the mismatch between student needs and supports given for students with disabilities during the COVID-19 pandemic. J Microbiol Biol Educ. 2022; e00280–e21. https://doi.org/10.1128/jmbe.e00280-21 PMID: 35496702

86. Kostaki D, Karayianni I. Houston, we Have a Pandemic: Technical Difficulties, Distractions and Online Student Engagement. 2021.

87. Fowers A, Wan W. Depression and anxiety spiked among black Americans after George Floyd’s death. Washington Post. 12 Jun 2020. https://www.washingtonpost.com/health/2020/06/12/mental-health-george-floyd-census/. Accessed 9 Nov 2021.
88. Mental Health—Household Pulse Survey—COVID-19. 19 Oct 2021 [cited 9 Nov 2021]. https://www.cdc.gov/nchs/covid19/pulse/mental-health.htm

89. Curtis DS, Washburn T, Lee H, Smith KR, Kim J, Martz CD, et al. Highly public anti-Black violence is associated with poor mental health days for Black Americans. Proc Natl Acad Sci. 2021; 118. https://doi.org/10.1073/pnas.2019624118 PMID: 33875593

90. Schad A, Layton RL, Ragland D, Cook JG. Uncovering the compounding effects of COVID-19 and racism on mental health disparities among biomedical PhD and MD students. medRxiv. 2021.

91. Steele CM, Aronson J. Stereotype threat and the intellectual test performance of African Americans. J Pers Soc Psychol. 1995; 69: 797. https://doi.org/10.1037/0022-3514.69.5.797 PMID: 7473032

92. Nguyen H, Ryan A. Does Stereotype Threat Affect Test Performance of Minorities and Women? A Meta-Analysis of Experimental Evidence. J Appl Psychol. 2008; 93: 1314–34. https://doi.org/10.1037/a0012702 PMID: 19025250

93. Wendt D, Shafer K. Gender and Attitudes about Mental Health Help Seeking: Results from National Data. Health Soc Work. 2016; 41: e20–e28. https://doi.org/10.1093/hsw/hlv089

94. Haavik L, Joa I, Hatlay K, Stain H, Langeveld J. Help seeking for mental health problems in an adolescent population: the effect of gender. J Ment Health. 2017; 28: 1–8. https://doi.org/10.1080/09638237.2017.1340630 PMID: 28719230

95. Mackenzie C, Gekoski W, Knox V. Age, gender, and the underutilization of mental health services: The influence of help-seeking attitudes. Aging Ment Health. 2006; 10: 574–82. https://doi.org/10.1080/13607860600641200 PMID: 17050086

96. Colvin JW, Ashman M. Roles, risks, and benefits of peer mentoring relationships in higher education. Mentor Tutoring Partnersh Learn. 2010; 18: 121–134.

97. Frisby BN, Martin M. Instructor–Student and Student–Student Rapport in the Classroom. Commun Educ. 2010; 59: 146–164. https://doi.org/10.1080/03634520903564362

98. Rimm-Kaufman S, Sandilos L. Improving students’ relationships with teachers to provide essential supports for learning. Teacher’s Modules. Am Psychol Assoc Off Site. 2011.

99. Hoffman EM. Faculty and student relationships: Context matters. Coll Teach. 2014; 62: 13–19.

100. Phirangee K, Epp CD, Hewitt J. Exploring the Relationships between Facilitation Methods, Students’ Sense of Community, and Their Online Behaviors. Online Learn. 2016; 20: 134–154.

101. Salehi S, Cotner S, Azarim SM, Carlson EE, Driessen M, Ferry VE, et al. Gender Performance Gaps Across Different Assessment Methods and the Underlying Mechanisms: The Case of Incoming Preparation and Test Anxiety. Front Educ. 2019; 4: 107. https://doi.org/10.3389/feduc.2019.00107

102. Schrank Z. An Assessment of Student Perceptions and Responses to Frequent Low-stakes Testing in Introductory Sociology Classes. Teach Sociol. 2016; 44: 118–127. https://doi.org/10.1177/0092055X15624745

103. Harris RB, Grunspan DZ, Pelch MA, Fernandes G, Ramirez G, Freeman S. Can Test Anxiety Interventions Alleviate a Gender Gap in an Undergraduate STEM Course? Price R, editor. CBE—Life Sci Educ. 2019; 18: ar35. https://doi.org/10.1187/cbe.18-05-0083 PMID: 31397651

104. Gin LE, Scott RA, Pfeiffer LD, Zheng Y, Cooper KM, Brownell SE. It’s in the syllabus… or is it? How biology syllabi can serve as communication tools for creating inclusive classrooms at a large-enrollment research institution. Adv Physiol Educ. 2021; 45: 224–240. https://doi.org/10.1152/advan.00119.2020 PMID: 33825519

105. Arias-de la Torre J, Vilagut G, Serrano-Blanco A, Martín V, Molina AJ, Valderas JM, et al. Accuracy of self-reported items for the screening of depression in the general population. Int J Environ Res Public Health. 2020; 17: 7955. https://doi.org/10.3390/ijerph17217955 PMID: 33138196