



Impacts of a COVID-19 E-Service-Learning Module in a Non-Major Biology Course[†]

Sarah Adkins-Jablonsky,^a Ryleigh Fleming,^a Marco Esteban,^b Diana Bucio,^a  J. Jeffrey Morris,^a
and Samiksha Raut^a

^aDepartment of Biology, University of Alabama at Birmingham, Birmingham, Alabama, USA 35294

^bDougherty Valley High School, San Ramon, California, USA 94582

Educators need to create an informed scientifically aware citizenry, especially in the era of the COVID-19 pandemic, where public health measures have focused on increasing adoption of safe behaviors for reducing the transmission of COVID-19. Non-major science students make up an important, yet understudied, part of our public, given that they constitute tomorrow's voters, workers, consumers, and policy-makers. Expecting that non-majors may benefit from a module connecting COVID-19 to community education, we implemented a novel E-service-learning module in light of the transition from an in-person course to an online platform. Our 4-week module included expert-led lectures, assigned digital infographics about COVID-19 safety precautions, and a required post-reflection assignment summarizing their learning gains. Out of 112 enrolled students, 87 consented to have their reflections analyzed and 8 students chose to participate in additional one-on-one online interviews. In an effort to determine which parts of our module garnered the most student commentary, we grouped post-reflection and interview data into four categories: service-learning infographic, service-learning guest lectures, information on COVID-19, and the broader implications of COVID-19. While 13% of students explicitly referenced infographics in their reflections, a far greater proportion (37%) explicitly referenced learning gains related to the expert-led lectures. Based on these findings, we encourage other educators to continue to explore the impact of E-service-learning content and assignments to help maximize learning in an online classroom environment during the COVID-19 pandemic and beyond.

INTRODUCTION

For many people in higher education, March 2020 began as just another month on the calendar filled with in-person classes and meetings. By the end of March, a different story was unfolding. On March 11, 2020, the World Health Organization declared COVID-19, a disease caused by the SARS-CoV-2 virus, a global pandemic (1–3). In March, stay-at-home and safer-at-home orders meant that higher education needed to begin relying heavily on online platforms as COVID-19 cases continued to climb. As of October 2020, there had been over 1 million global deaths due to this disease (1). Among the most important factors in reducing human-to-human respiratory transmission (3) is education about physical distancing, wearing of facial masks, and advocacy for routine testing (1). Evidence has shown that informing people about COVID-19 and its risks correlated with a

positive attitude toward adopting safe behaviors (4), and recent studies have shown connections between education and decreased viral transmission (5), particularly among health care workers (6). Meanwhile, the general public's primary source of information may be social media platforms like Twitter or Facebook, which can contribute to the spread of misinformation, leading to what is known as an “infodemic” (7–10). Given the fact that non-biology majors (which we refer to as non-majors) represent an important segment of tomorrow's voters, workers, consumers, and policy-makers, it is important that approaches to COVID-19 education and combatting the infodemic are targeted toward this population. Notably, however, previous studies have indicated some unique challenges in non-major populations, including negative attitudes toward science (11), decreased motivation to learn and participate in science (12), lower overall interest in STEM fields, and gaps in understanding the nature of science and science content knowledge (13).

A pedagogy uniquely poised to enhance scientific content using community-based education is service learning (SL). SL aims to connect classroom content with relevant needs of a community, reciprocally benefiting both the students and a community partner, such as stakeholders at a local nonprofit or community-based organization (14–19). The community partner should have specific needs met by the student's

Address correspondence to Department of Biology, University of Alabama at Birmingham, Birmingham, Alabama, USA 35294. E-mail: sraut@uab.edu.

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service that are compatible with an instructor's learning objectives for the course (14–19), implying that SL involves both a community-relevant project and corresponding lecture content. Common student outcomes related to the adoption of SL are focused on improving understanding of the course material (16), increasing science values (17), awareness of social issues (18), and improving civic skills (19), making SL an apt pedagogy to use with non-majors. Despite the fact that courses targeting non-majors continue to remain understudied in the STEM literature, some evidence suggests that SL can be used as an effective community engagement tool for these students. For example, a recent study by Mendoza et al. showed that incorporating SL in a non-major biology course can increase awareness of a global issue like climate change (20), and another study showed SL led to changes in non-major's attitudes toward problems existing in their communities (21).

We decided to integrate a SL module into our non-major biology course after the COVID-19 campus shutdown in order to engage students in understanding more about COVID-19 and its impact on their communities. Previously, a similar approach was adopted by Larios-Sanz and colleagues in educating their students around other contemporary diseases (22). Their team showed that having students create informative brochures in the context of a SL biology course increased student understanding of a disease topic (22). However, their curriculum was implemented as an in-person, semester-long project, which was not feasible under COVID-19 restrictions, nor is it directly applicable to an online platform. We made use of an alternative, yet still practical, pedagogy, “E-service learning,” which translates SL to an online format (23, 24) and targets outcomes comparable to an in-person SL experience (25). SL and E-service learning are also similar because they both help students to connect course material with their own personal insights into community service (14, 25). However, in an E-service-learning experience, neither students nor community partners are bound by in-person participation events. This in turn can influence who can participate (26), contributing to blurring the line between student and community partner (27). Beyond a more inclusive definition of community partnership (28), E-service learning can be inclusive of students who otherwise may not be able to participate in person due to their geographical location or disability status (23). Another feature of E-service learning, compared with in-person SL, is its ability to make use of social media. Indeed, social media serves as a major source for disseminating knowledge related to health education (7). It is not surprising that E-service-learning courses that make use of social media platforms have been shown to foster a sense of personal connection to course objectives (29).

In this study, we developed a SL COVID-19 module for a non-major introductory biology course after the class was transitioned to an online instructional mode in spring 2020. The module included an E-service-learning component of expert-led guest lectures and infographics

created by the students to educate and spread awareness about COVID-19. We analyzed 87 post-reflections submitted by the students and conducted eight one-on-one student interviews exploring the following question: Which parts of our module did students reflect on during their post reflections? Our goal was to highlight student outcomes that may help inform those educators who may be interested in implementing pedagogical techniques to engage undergraduates on an online platform during the COVID-19 pandemic and beyond.

METHODS

Course context and COVID-19 module

The University of Alabama at Birmingham (UAB) offers a large-enrollment course entitled Contemporary Topics of Biology. This course has no prerequisites and is open to all non-majors fulfilling their general science requirement. In Spring 2020 (10-week semester), SR taught the lecture course twice a week (Tuesday and Thursday) for 75 min. This course enrolled students from several different majors, including psychology, art, education, music, social work, prenursing, criminal justice, public health, communication, political science, English, health care management, marketing, computer science, African American studies, finance, and economics. The course began with a module focused on the scientific method, which enabled students to understand the differences between credible and noncredible sources. It also included an in-person SL module on the current opioid epidemic (student outcomes from this activity are not reported here). Immediately following UAB's spring break, Contemporary Topics of Biology, as well as its SL component, moved to an online format for the remainder of the semester, and thereafter, students met synchronously online during the weekly assigned class meeting times. An additional SL module on COVID-19 (Table 1) was promptly introduced as the course moved to a virtual platform, with the goal of educating the students about the ongoing pandemic via guest lectures and an infographic assignment (see exemplar student infographics in Fig. 1).

Post-reflection and student interviews

The post-reflection prompt can be found in Appendix 2, and the rest of the course grade distribution from the syllabus can be found in Appendix 3. The required post-reflection was completed by 112 students and, after an informed consent and a statement of confidentiality (including participation not being known to instructor SR nor participation affecting student's final grades), 87 students consented to participate in this research study (78% participation rate). We also invited consenting students to participate in one-on-one student interviews via UAB-hosted Zoom meetings (interviews managed by SA). Eight students chose to participate in these interviews, which began with

TABLE I
Online transition and SL module

Objectives
Course learning objectives: • Understand the basic process of science and identify the valid sources of scientific literature • Analyze and apply scientific information to make everyday decisions • Gain a basic understanding of the cell and its functions as it relates to health and wellness
Module learning objective: Students will demonstrate a greater awareness about the COVID-19 pandemic by: • Creating an informational infographic and sharing their infographic with their peers • Describing their own learning gains related to COVID-19 biology and public health
Assessment
Infographic Students, in teams, were required to create an infographic, which was graded in lieu of the final exam (15% of final grade). See Infographic assignment instructions in Appendix I. Assignments were graded based on the inclusion of scientific information related to the pandemic as specified in the instructions, including basic science about COVID-19, the national and global implication of the virus, physical distancing, and information about how people are affected. Students were graded by their peers (peer-evaluation) and the teaching team. Infographic examples are shown in Fig. I and rubrics are included in Appendix I.
Post-reflection Students were required as a part of their course grade (10% of final grade) to complete a post-activity reflection about the SL module and activity. Post reflections were graded entirely on completion (they earned a 100% or completing the assignment regardless of their responses).
COVID-19 module
Guest lectures The interactive lectures specific to the new COVID-19 module included the following: • A basic introduction to viruses, replication, epidemiological principles, and vaccines (taught by SR) • Two public health discussions on physical distancing, safety guidelines and public health (taught by two UAB School of Public Health–affiliated faculty, Ana Oliveira and Bertha Hidalgo) • A lecture on intubation, ventilators, and chest X-rays (taught by Children’s of Alabama Emergency Radiologist Sumit Singh) • An interactive discussion where a patient shared his experiences being diagnosed with and treated for COVID-19
Infographic Students, in teams of four to five, were tasked to create a visual presentation (such as a digital flyer, pamphlet, or poster—the “infographic”) to raise awareness about COVID-19. These infographics were shared through UAB News media portal (https://www.uab.edu/news/research/item/11312-uab-professor-led-students-to-develop-covid-19-awareness-campaign-for-community-health-and-safety) and UAB’s Department of Biology social media websites (including the @UAB Biology Instagram account, which has over 500 followers) and also with each student’s immediate circle of friends and family (students were told to share their infographics with two or three people). Notably, the assignment led one team of students to create a new student-driven Instagram account (@uab.awareness; https://www.instagram.com/uab.awareness/) which is now being used as a library of infographics and podcasts related to this course, with 160 followers at the time of this article’s publication.

an explanation of the privacy and confidentiality statement and a reading of the post-reflection prompt as detailed above. No further prompts were given; students were free to discuss anything they had on their mind related to the initial prompt or anything else in the class. The interview followed a semistructured approach where interview follow-up questions were based on the previous comments. These interviews ultimately provided a way for students to discuss experiences in the class in a format that was not graded, in contrast to the reflection assignments. Student interviews were transcribed, and personal information

was removed prior to analysis. This study was approved by the University of Alabama at Birmingham IRB-300004903.

Data analysis

Two individual coders separately read all 87 student post-reflection essays (authors RF and DB). The coders decided on the four categories after consultation with the instructor (SR) in order to represent aspects of the module that could potentially be replicable for other instructors (infographics and lectures) as well as other information

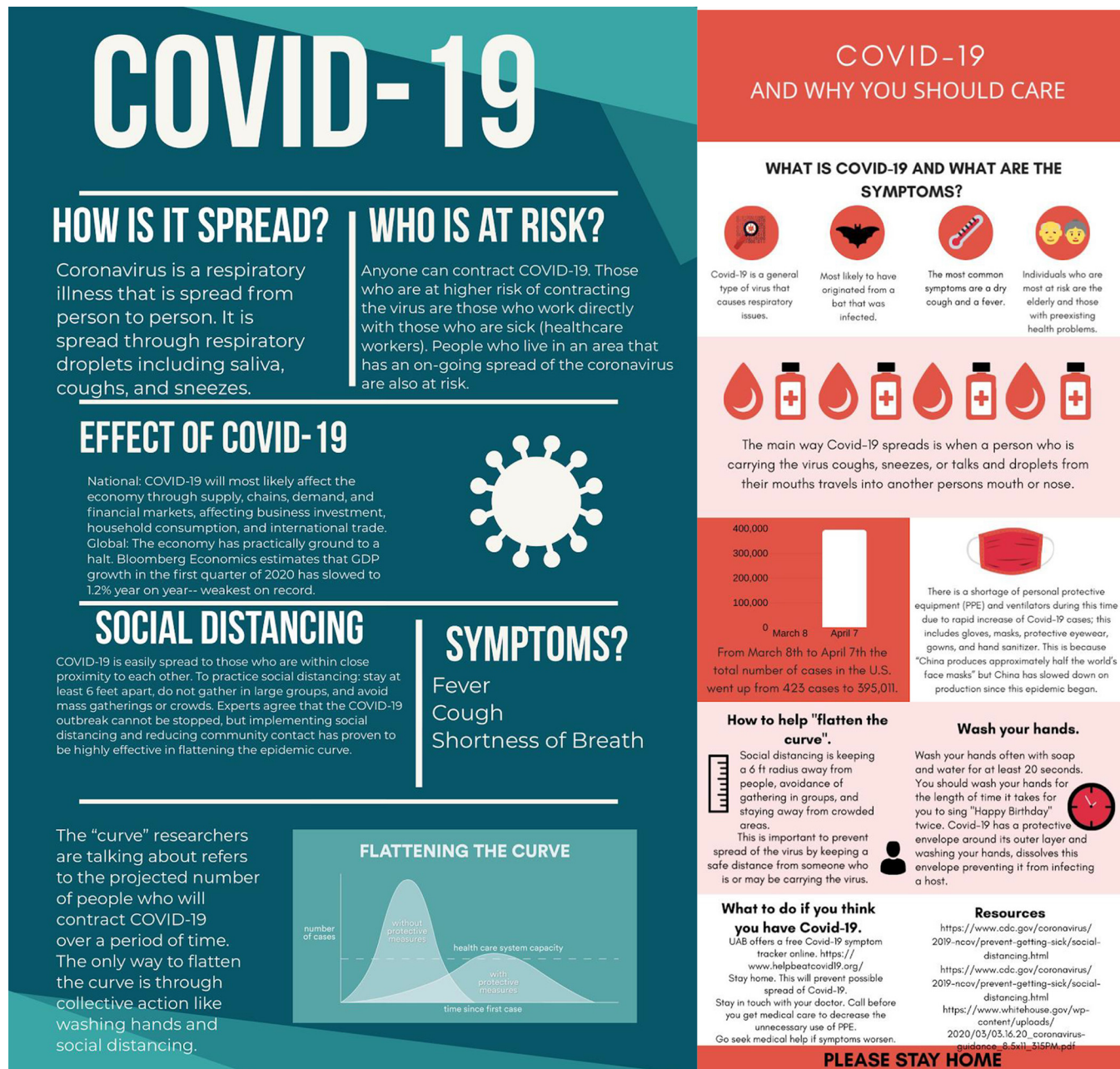


FIG 1. Examples of infographics made by Contemporary Topics of Biology spring 2020 student teams (the left infographic was created by Team "S-Layer" and the right infographic by Team "Raging Fossils").

students learned about COVID-19. The four predetermined categories were:

1. **Service-Learning Infographic (abbreviated "Service-Learning").** Themes related to the service-learning assignment fell into Category 1. An example of a theme in this category is students reflecting on the creation or implementation of service-learning infographics.
2. **Service-Learning Lectures (abbreviated "Lectures").** Themes related to the course content or its delivery were included in Category 2. A

theme would fall into this category if students explicitly stated the information they learned came from the course lecture content.

3. **COVID Information.** Themes about facts related to COVID-19 which directly relate to the service-learning project or lectures fit in Category 3. For example, if students described why it was important to physically distance but did not explicitly state they learned about it from the course lectures, it was included in this category.
4. **COVID-19 Other.** Themes that did not fit into the above categories were aggregated into Category 4. For

example, the connection of COVID-19 to broader social issues were in this category.

The coders separately devised open coding themes (inductive) (30) that could fit into one of the four predetermined categories (deductive). Coders next discussed their respective themes and came to a consensus regarding themes that were mutually agreed upon by both the coders. We decided to use flat frame coding in each category, where codes are not grouped into more subthemes, because we already had decided on broad categories. The coding of the student interviews followed the same workflow, but with different coders (author ME and researcher Cedric King), to ensure that their inductive coding was not influenced by the inductive coding of the student reflections.

RESULTS

After we analyzed themes across 87 student post-reflections, we found trends across the four categories (Fig. 2). All themes are shown in Appendix 4 (Table S1). After comparing with our post-reflections, we found that related themes emerged from our eight one-on-one student interviews (Table 2).

Category 1 (Service-Learning)

Seven themes emerged about SL infographic activity. The most common were gratitude for being able to participate (13% of responses), the project being eye-opening (7% of responses), and the project enabling use of credible sources (6% of responses). Less common themes included the project being helpful, students being able to teach their peers, the project being innovative, and the project putting students at ease (Appendix 4, Table S1). Nearly all of the student interviewees (7 of 8) expressed support for the SL aspect of having to create and use their infographics. There were no criticisms about SL mentioned beyond one student wishing they also had an opportunity to take a final exam (which was removed to make room for the SL assignment). Two interviewees mentioned they were grateful for the teaching assistants who helped transition the course online.

Category 2 (Lectures)

There were seven themes related to the SL lectures. Students commonly reported that the SL lectures gave them a deeper understanding of facts about COVID-19 (37% of responses), helped them to understand that this virus needs to be taken seriously and the necessity of following public health guidelines (32%), and that they felt especially well-informed about COVID-19 because of the lectures (13%). Some students considered it noteworthy to hear from a COVID-19 survivor about his personal experience dealing with the virus (5% of student responses) (Appendix 4, Table S1). Four of the eight student

interviewees mentioned the usefulness of the course lectures and guest speakers. One interviewed student stated, "Even if we had that [COVID-19] module but didn't have the guest lectures, I don't think it would have been as effective as it was," and another student said having the lectures online allowed her family to also watch them (Table 2), an unintended but nevertheless beneficial consequence of the online transition. Three of eight interviewed students appreciated that the course had pivoted to a relevant topic compared with the previously planned lecture content.

Category 3 (COVID-19 Information)

Category 3 had the greatest number of themes, with 36 in total. The most prominent theme across all categories was students responding that they understood the value of physical distancing and staying home when possible (67% of student responses). A majority of students also indicated they understood the modes of transmission (58%) and that COVID-19 was a pandemic or epidemic (58%). Slightly less than half (43%) of students reported realizing COVID-19 existed before the pandemic. A similar number (42%) explained that people of all ages are at risk of complications from COVID-19, especially if they have preexisting health conditions or are immunocompromised. Less common themes for Category 3 were that the United States is leading the world in the number of confirmed cases and deaths (7%), that they could explain the reason for the COVID-19 and SARS-CoV-2 names (9%), or that an outbreak could happen again (5%). From the interviews, we found half of the interviewees demonstrated growth in their knowledge related to COVID-19, e.g., learning that the virus can spread via asymptomatic individuals (Table 2).

Category 4 (COVID-19 Other)

This category had 33 themes. The most common themes found across student responses were: the pandemic affecting the school system (30%), the pandemic has caused people to lose their jobs or turn to unemployment benefits (27%), there is an overall lack of testing supplies, personal protective equipment (PPE), and ventilators (26%), and that COVID-19 has caused hospitals to become overwhelmed (25%). Some of the less common themes in Category 4 were that students knew there had been a shortage of pandemic-related goods (e.g., cleaning and hygiene products) (2%), students acknowledging the protests against government responses to COVID-19 (2%), and students reporting that the U.S. government has provided the public and media outlets with incorrect information (2%). Two of eight interviewees mentioned that they were paying attention to how the pandemic exacerbated inequalities in health care.

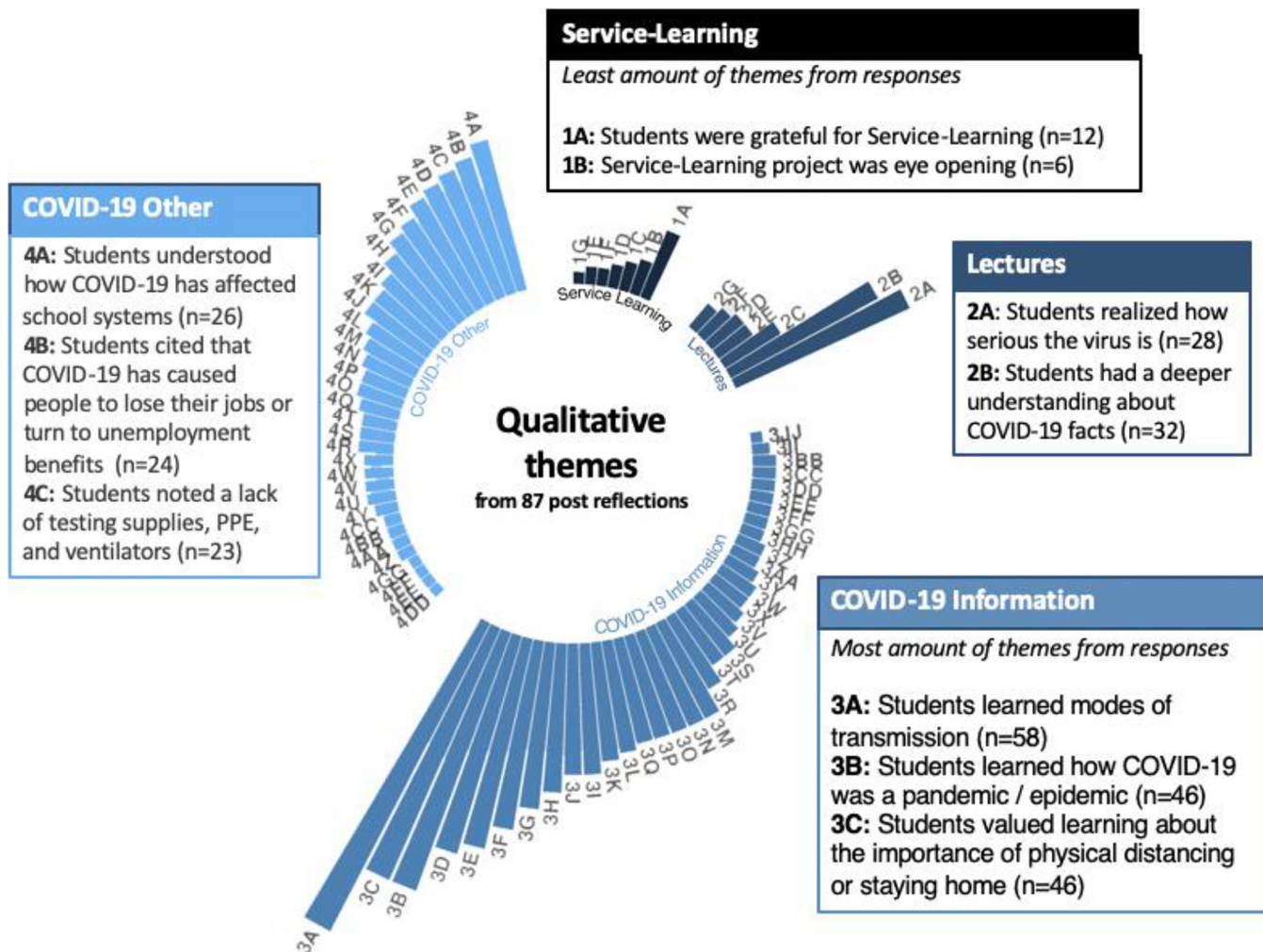


FIG 2. Prevalence of qualitative themes from student reflections. Bar lengths are proportional to student responses for specific themes (a full list of themes is available in Appendix 4, Table S1); bars may not necessarily be in alphabetical order but are in numeric order. The most common themes and the number of students whose post-reflections included that theme are next to its corresponding bar plot.

DISCUSSION

Our module included five synchronous COVID-19-related lectures, four of which were delivered by outside experts: a medical doctor, two public health professors, and a formerly COVID-19-positive patient. Students then worked in teams of four for a SL project to create an infographic relaying accurate information about COVID-19. These infographics would be used by the department and shared with the student's family and friends. We wanted to ascertain student learning gains from this module and, specifically, highlight aspects of the E-service-learning module that played a key role in the learning gains. Findings from this study could help inform other educators about strategies they could deploy in their respective classrooms to educate students about COVID-19, especially if they are considering implementing similar E-service-learning modules.

When students discussed infographics in their post-reflections, they mentioned gratitude, especially for being able to discuss course content with their friends and family, which is

relatable to a study reporting that SL promotes personal outcomes (29). More student responses were connected to E-service-learning lectures than to the E-service-learning infographics (Fig. 2; Appendix 4, Table S1). This may be partially explained by the fact that the post-reflection prompt asked students to report "anything new that [they] may have learned because of this module," without explicitly asking where they had initially learned this information. Students may associate lectures with content learned and the SL assignment with their own personal experience (23, 29, 31), which could explain why lectures were explicitly mentioned more often in their reflections. Perhaps not having one exclusive SL partner, as is the norm for an in-person SL curriculum, may have influenced our students' perceptions of the module. Regardless, guest lectures as a pedagogical tool, especially in SL, continues to be understudied. A previous study demonstrated that guest lectures can promote understanding of the content by showing students novel perspectives beyond their instructor's (32), but this work was not specific to SL curricula. In our case, the perspectives of a doctor and a COVID-19 patient were

TABLE 2
Most common themes from student interviews

Theme code	Example quotes	% of student interviews including theme (N = 8)
Service-Learning (Category 1)		
Support for SL (talking to family and friends, pamphlet, flyer)	“Because my sister, she actually got her degree in public health, so hearing her standpoint on it and being able to talk to her about it was actually really interesting too.” – Student 5 “I liked [the pamphlet and flyer] a lot because I’m in marketing. I actually really enjoy doing graphic design. I really enjoy creating poster boards and infographics. That was something I really enjoyed and I’m really good at doing it. I like researching different subjects.” – Student 6	75% (n = 7)
Positive review of TAs work online	“TAs that, they would hold review sessions for us, which, I think they actually prepared me for the test a little better than the regular lectures, but they were so awesome and they really tried to keep in touch with us and make sure that we got our assignments done—once we transferred to online.” – Student 1	25% (n = 2)
Lectures (Category 2)		
Support for course lectures and guest speakers	“I think it did just because you know, you can look stuff up on the internet, but you don’t always know what’s true. So, I think it helps to have a person in the research or medical field who is directly involved with it in person telling us these things. . . my mom actually watched Dr. Singh’s lecture with me because she was pretty interested in it.” – Student 2	50% (n = 4)
Course was relevant	“I definitely enjoyed it because it was relevant. It was informative about what’s actually going on.” – Student 2	38% (n = 3)
COVID-19 Information (Category 3)		
Knowledge of COVID (testing centers, safety)	“I just thought it was really interesting that a lot of people are actually asymptomatic and not a lot of people know whether or not they have the virus. They could potentially be spreading it without even knowing it. Also, we don’t have very many testing centers or whatever, especially when the virus started to really break out especially here in Birmingham so it was hard to see and know who had the virus and how, I don’t know, I guess contain it as best as possible.” – Student 5	50% (n = 4)
COVID-19 Other (Category 4)		
Inequalities in healthcare	“I wrote my essay mostly on issues like income inequality and peoples, marginalized people not having as good of access to health care and things like that during this crisis. Just like . . . this crisis has sort of put a magnifying glass on everything that was already wrong with our society. . .” – Student 1	25% (n = 2)

Responses are grouped by category related to the COVID-19 module.

considered especially valuable by our students. Since it was the goal of the instructor (SR) to help create an informed citizenry around contemporary issues, we consider this objective was met by the inclusion of guest lectures, which represent an invaluable element of our SL course design.

Student reflection essays were written in mid-April 2020, before the active implementation of public health measures like physical distancing and mask decrees. Our observations reveal that 7% of students were able to explain that the United States was leading the world in COVID-19

deaths and cases, accurately reflecting the most current information regarding the pandemic (33). We found no student themes that overlapped with common COVID-19 misconceptions as shared on social media (7). Through an analysis of Tweets from January to March, Singh and colleagues found Twitter users were likely to share unsubstantiated beliefs, such as saying COVID-19 is the same as the flu, summer heat can kill the virus, home remedies can cure the disease, the virus originated as a biological weapon, and vaccine information is being hidden by governments (7). Indeed, 16 of our 112 students included in their post reflections that misinformation was spreading on social media (Appendix 4), and 2 of our 112 students reflected that this was due to information coming from the U.S. government (Appendix 4), but it was not apparent that they themselves shared these beliefs given their reflections indicated no signs of misinformation. Although we did not specifically assess student attitudes toward these theories, our analysis of their post-reflections across 36 different themes specific to the virus clearly suggests that students left the course with evidence-based COVID-19 beliefs. This type of knowledge can be ultimately correlated with a decrease in the transmission of the SARS-CoV-2 virus (5, 6).

The fact that 5% of our students reported explicitly reflected on their stress during the online transition (Appendix 4, Table S1) aligns with previous work, which showed that students experienced a decrease in focus or motivation, found it difficult to learn online, and experienced challenges in discussing course content with their peers (34). It is likely that some of our students were experiencing compounded psychological stress in their additional roles as workers or caregivers. Indeed, other researchers found that clinical psychological distress among professional students was quite common following the COVID-19 outbreak. In the light of these stressors, it is important for educators to create equitable teaching practices (34) to foster an inclusive learning environment for all students. Themes from the post reflections further reveal that students saw COVID-19 as more than just a virus, but as a phenomenon with a long-lasting impact on student's own lives. Social determinants of health care were incorporated in the public health guest lectures; topics like racial and income inequities related to COVID-19 came up in two interviews and nine post reflections. Many students reported that they still have a desire to make a difference (20%) in their community as opposed to those students who explicitly mentioned their infographics (4%) in the context of SL. It is possible that the infographic SL assignment did not help satisfy a student's desire to serve their communities in a concrete way. SL assignments that provide students an opportunity to select their own SL project among multiple options, like writing letters to health care workers or sewing masks, may more obviously fulfill this desire (35).

Limitations

We did not anticipate the pandemic toward the start of the spring 2020 semester and our study is therefore

limited by the lack of pre-reflection data summarizing the attitudes of the students toward COVID-19. We acknowledge our research methods may have been different if we had been able to anticipate the campus closure, but we nevertheless found compelling themes within student responses that can substantiate our claim that the modules had an impact on student learning. Even though students' writing may have been influenced by the fact that their writing assignments were being graded, analyzing these assignments offers a straightforward means of measuring learning outcomes without adding unexpected additional surveys to the course. In addition, there may have been self-selection bias for the eight students who willingly spent uncompensated time with us on Zoom interviews. We found that encouraging student participation is increasingly more difficult when students may already be experiencing Zoom fatigue (36). Nevertheless, eight student interviews represented almost 1/10 of the students who consented to allow us to use their post-reflection data, which is on par with our former, in-person interview participation rate of 10% (20) for a comparable class size. We find this rate quite promising in terms of continuing to do Zoom interviews in lieu of in-person interviews. Going forward, we realize that the present study provides opportunities for future studies. Many of the themes are worthy of their own separate in-depth analysis as future directions. For example, are students still using credible sources and scientific facts to influence their behavior? Have students shared their infographics with people since the course ended, and if so, how were their discussions different than they were at the onset of the pandemic? Are students still anxious and hopeful about a vaccine? We expect that educators who continue to inquire about student perspectives will further explore these questions to better inform others about classroom experiences. As we adjust to the current online educational landscape, it is imperative that we likewise adjust how we implement active-learning pedagogies and student assessments.

CONCLUSION

This study presents a 4-week adjusted online curriculum, including an array of expert-led guest lectures, which used SL infographics and graded post-reflections to assess student outcomes. Our main findings were that students referenced expert-led guest lectures more often than they referenced their infographic assignment, but overall all reported learning correct information and practices about COVID-19. While our study targeted non-major biology students during an unexpected crisis at a single university, we are hopeful that our work can inform future efforts toward the broader integration of SL and expert-led lectures into remote learning in

science curricula, benefitting diverse learners under a variety of circumstances.

SUPPLEMENTAL MATERIALS

Appendix 1: COVID-19 activity and rubric
 Appendix 2: Student post-reflection prompt
 Appendix 3: Course syllabus (prior to online transition)
 Appendix 4: Table S1

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