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| Research Article

Non-STEM majors COVID-19 vaccine impressions improve, and misconceptions resolve, after podcast assignment

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ABSTRACT Misinformation regarding vaccine science decreased the receptiveness to COVID-19 vaccines, exacerbating the negative effects of the COVID-19 pandemic on society. To mitigate the negative societal impact of the COVID-19 pandemic, impactful and creative science communication was needed, yet little research has explored how to encourage COVID-19 vaccine acceptance and address misconceptions held by non-Science, Technology, Engineering and Mathematics majors (referred to as non-majors). We have previously demonstrated that including expert guest lectures in the vaccine module in the non-major introductory biology course helps combat students' vaccine hesitancy. In the present study, we further address how learning about vaccines impacts student knowledge and impressions of the COVID-19 vaccines through a podcast assignment. As a part of this assignment, non-majors created podcasts to address COVID-19 vaccine misconceptions of their choice. We coded pre and post, open-ended essay reflections (n = 40) to assess non-majors' knowledge and impressions of the COVID-19 vaccines. Non-majors' impressions of the vaccines improved following the podcast assignment with more than three times as many students reporting a positive view of the assignment than negative views. Notably, eight of the nine interviewed students still ended the course with misconceptions about the COVID-19 vaccines, such as the vaccines being unnecessary or causing fertility issues. In a post semi-structured interview following this assignment, students (n = 7) discussed the impact of looking into the specific misconceptions related to COVID-19 vaccines themselves, including improved science communication skills and understanding of different perspectives. Thus, podcasts can provide opportunities for students to improve engagement in valuable societal topics like vaccine literacy in the non-majors classroom.

KEYWORDS vaccine misconception, COVID-19, non-majors, podcast, vaccine hesitancy

National calls for reforming Science, Technology, Engineering, Mathematics (STEM) undergraduate education have led to a substantial increase in the use of active learning pedagogies which aim to center student learning and improve student outcomes (17). While many college classrooms continue to remain lecture-based, wherein instructors teach from lecterns in an auditorium (1, 2), active learning strategies structure class time such that students engage with instructional content (2–8). Remarkably, active learning has shown to reduce failure rates and close equity gaps (7, 9) in a STEM classroom while concurrently increasing student learning (10) and self-efficacy (11).

Podcast assignments are one such active learning pedagogy which provide students hands-on opportunities to explore course content and communicate with diverse communities (12). Approximately 80 million Americans listened to podcasts in 2020 (13), with a majority of listeners being adolescent and college-aged (14). Their ubiquity has led to podcasts being used as part of higher education (15–17). Podcasts facilitate

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student engagement with complex material (18, 19) asstudents may intentionally seek to communicate such ideas to broad audiences (20–24). When exposed to podcasts as part of their classroom education, students refine their ability to synthesize and effectively communicate what they learn (18) and increase their motivation to learn the course content in-depth (25). Additionally, having used podcasts as part of their learning once, students continue to listen to podcasts to further their education after the class is over (26). Thus, podcasts provide students with an avenue to spark conversations about the content beyond the classroom (27). In this way, podcasts can allow students to engage in a community issue while mastering course-learning objectives.

Reforming STEM education with active-learning pedagogies would add value for all students, but especially those often left out of education reform conversations, for example, non-majors (28, 29). Even though three times as much education research is done on STEM-major classes (30), over half the college-educated workforce earn degrees outside of STEM disciplines (31, 32). For non-majors, the courses that fulfill their science graduation requirement may also be the only opportunity for students to gain scientific literacy, which has downstream societal impacts on contentious debates such as climate change (33, 34), evolution (35, 36), genetically modified organisms (34, 35, 37), and vaccine acceptance (38–41). Given the heavy influence of social media on the public opinions on these divisive topics (42), when shared over social media platforms, podcasting offers an opportunity for students to harness these platforms to become community educators under the guidance of expert instructors (43, 44). In fact, when used in non-majors STEM classes, active-learning pedagogies can: (i) address the difficulties non-STEM majors have in recognizing how the course content can be applicable to their lives and interests (16, 23), (ii) improve low overall interest in STEM (45), (iii) ameliorate broad, negative attitudes toward science, and (iv) increase their motivation to learn and participate in science (46). It is, thus, imperative to implement engagement strategies that help connect the learning objectives through timely societal topics of interest impacting the student's lives and is critical for non-majors STEM students (47–49).

Though students at our university have produced podcasts outside of the classroom (27), the present study is the first time a podcast module was embedded into our non-majors biology course. This module included lectures that covered vaccine science, SARS-CoV-2 virology, SARS-CoV-2 vaccine development, and efficacy (in accordance with the way they are more commonly reference to colloquially, we here will be referring to these vaccines as "COVID-19 vaccines"). The lectures also covered historical and ongoing science and medical disparities, as well as unethical research and treatment practices that may impact vaccine hesitancy. Students then participated in question and answer sessions with an epidemiologist and a practicing infectious disease physician (30). Following this introduction, in groups of 3–4, students were tasked to create a podcast by following this prompt "delve more deeply into an ongoing misconception around COVID-19 vaccines and create a podcast that will be made available to the public to help combat the rampant misinformation online." When students consented, completed course assignments were posted on the course social media platform, Instagram @uab.awareness, a page moderated by author SAR through the Biology Department at the University of Alabama at Birmingham (43). The assignments were posted without students' names. This platform provided a space for the students to share the podcasts they created through social media.

The decision to have students create podcasts related to COVID-19 vaccines was a timely intervention toward mitigating the spread of SARS-CoV-2 infections and COVID-19-related misinformation. While SARS-CoV-2 infection can act as a barrier to re-infection similar to vaccination, at the time of this study (Spring 2021), the infection rates were dramatically lower, and thus, vaccination was espoused as a primary way of infection control. The spread of misinformation and misconceptions related to COVID-19, which became known as the "infodemic" (50–52), made its way into households across the globe via computers, tablets, and smartphones. Moreover, the

"infodemic," particularly in populations with lower scientific literacy, has contributed, in part, to dwindling vaccination rates and lower COVID-19 prevention strategies (53, 54). As of Feb 1, 2023, over 19% of Americans remain completely unvaccinated, while COVID-19 deaths surpass 1 million (55). Raising awareness by imparting the pertinent scientific information is paramount toward preventing the spread of COVID-19 among the general population, and non-majors are inclusive of this population (56–58). Thus, the non-majors introductory biology course included learning objectives specific to COVID-19 and vaccination. We have previously demonstrated that expert-led educational discussions can influence non-majors' willingness to get COVID-19 vaccines (30). The present study sought to evaluate the impact of empowering students to curate accurate sources and actively push back against misinformation. These skills are imperative for evaluating the credibility of information sources used to make informed decisions related to science and medicine. Little work to date has explored how active learning assignments, such as the podcast project described here, can be used to educate non-majors biology students about the COVID-19 vaccines.

Through this intervention, we explored the following research questions (RQ):

RQ1. What impact does a podcast assignment have on students' knowledge of the COVID-19 vaccines?

RQ2. What impact does a podcast assignment have on students' impression of the COVID-19 vaccines?

We expected that after completing the project, students would have a positive impression of the COVID-19 vaccines as well as the podcast assignments.

METHODS

Study recruitment

All participants included in this study were undergraduate students enrolled in a 3 credit-hour course entitled "Topics in Contemporary Biology (BY101)" at the University of Alabama at Birmingham (UAB) during the Spring 2021 semester (n = 97). This course was taught remotely by author SAR, has no prerequisite, and fulfills a general science requirement for non-majors. Prior to the podcast assignment, students learned pertinent course content via interactive lectures and question and answer sessions. The lectures by the instructor of record (author S.A.R. with assistance from C.N.M.) covered vaccine science, COVID-19 virology, COVID-19 vaccine development/efficacy, and lastly, historical/contemporary science and medical disparities/practices that may impact vaccine hesitancy. Additionally, students participated in presentations and question and answer sessions with an epidemiologist and practicing infectious disease physician (30). The course structure included a grading scheme comprising 300 total points including two exams (100 points each), a pre-COVID-19 vaccine awareness questionnaire (10 points), a post-COVID-19 vaccine awareness questionnaire (10 points), the podcast project (60 points), the pre-podcast reflection (10 points), and the post-podcast reflection (10 points). All students enrolled in BY101 during the Spring 2021 semester had to complete the IRB-approved form to indicate if they consented to be part of this study. Demographic information and response rate are available in Table S1.

COVID-19 podcast project

Students were required, as a part of their course grade, to complete a COVID-19 podcast project. This assignment sought to partially accomplish two of the six course-learning objectives. The pertinent learning objectives (LO) were to (i) understand the basic process of science and identify the valid sources of scientific literature and (ii) understand the biological basis of COVID-19 vaccination in the context of immunology and human physiology. This assignment tasked the students with delving deeply into an ongoing misconception around COVID-19 vaccines and create a related podcast. Students were given an option to have their podcast published on the course Instagram page @uab.awareness. They were informed that their choice to consent to publish this

podcast would not impact their grade. If all student authors consented, the podcast was published with only the students' first names in the byline. This Instagram account, where public science communication was noted as community need by members of the Biology Department, was founded by students during the previous semesters to help disseminate the information they had learned in this course and is now managed by the course instructor, author SAR.

Following established guidelines, students were organized into groups of about four students (59). Students were provided an instruction sheet for the assignment that included the rubric which was used to grade the assignment. Briefly, the assignment required that each group generate a 10–15 min podcast addressing a COVID-19 vaccine misconception using valid information sources, highlighted by the expert guest lecturers. Each group was further assisted in this activity by peer leaders. These peer leaders were UAB upper-class undergraduate students, graduate students, or postgraduates who had volunteered their time to facilitate this assignment. The peer leaders sent reminders about the assignment deadlines and provided general assistance as required for this assignment. The project was considered complete when the script was submitted, and the podcast recording was uploaded to anchor.fm (https://anchor.fm/). A companion article details how instructors can set up podcasts in their own classrooms (12).

Pre and post reflections

Students completed a pre and post reflection assignment (400–500-word limit) related to this assignment with the following prompts:

> "What do you know about the COVID-19 vaccinations? Why are some people getting (or want to get) a COVID-19 vaccine? Why do some people not want to get a COVID-19 vaccine? What might change someone's mind from not wanting to get a COVID-19 vaccine to wanting it?"

While 42 students consented, the analysis contains the results of the 40 consented students who completed both the pre and post reflections.

One-on-One interviews

To supplement reflection data, all consenting students were invited to take part in individual out-of-class interviews hosted on Zoom (Zoom.com). These interviews were semi-structured; based on the participating students' responses to the reflections and the following questions (also see Supplemental Box 1. Interview script guide):

> "How has the podcast activity affected your opinions of COVID-19 and its approved vaccines?", "What was your podcast about?" and "What knowledge did you gain from the podcast activity?"

Seven one-on-one interviews were conducted. While the intention was to interview additional students, the interviewed students represent 17.5% of the total study cohort, more than other published studies (43, 47), particularly in light of the well-documented phenomenon, known as Zoom fatigue (60). In consideration for interviewer influence, interview was not conducted by the course instructor. Furthermore, the interviews were conducted 8–12 days after the podcast assignment was due and after the course was complete.

Data analysis

Coding of the reflections

Coding of the reflections began with a deductive approach where the coders, authors B.J.C., M.L.H., and S.P.G., met with author C.N.M. to discuss the research questions guiding the analysis. Following this, the coding approach transitioned to an inductive approach to allow for the exploration of the data within the confines of the research questions (30,

TABLE 1 Student selected podcast topics. Students worked together in groups of three to four to identify a COVID-19 vaccine misconception to address as a podcast

Podcast topic
Do mRNA vaccines alter DNA?
The COVID vaccines weren't rushed
Comparing side effects of the COVID vaccines to other vaccines
Exploring long haul COVID
Safety First: is the COVID shot truly safe for your loved ones?
Misconceptions of the SARS-CoV-2 vaccines on infertility
One vaccine is better than another: a comparison of Pfizer, Moderna, and J&J
Infection- vs vaccine-induced immunity
COVID-19 vaccines are not safe while pregnant or breastfeeding
Masks are unnecessary after vaccination
COVID-19 vaccine side effects are worse than COVID-19 infection
COVID-19 infection can be caused by the vaccines

47, 61, 62). During this phase, coders separately read all pre- and post-reflections and individually devised open coding themes and subthemes that addressed the following research questions "What impact does an active learning podcast assignment have on students' knowledge of the COVID-19 vaccines?" and "What impact does an active learning podcast assignment have on students' impression of the COVID-19 vaccines?". Coders then discussed their respective themes and came to a consensus regarding the final themes, and subthemes when appropriate, that were mutually agreed upon by all three coders. Codes that applied to fewer than four respondents were not included in the tables below. To address the research questions above, the Fisher Exact Test was performed using the Fisher Exact Probability Test Calculator for a 2 × 3 contingency table evaluating the student impression of the podcast assignment. This was performed using Vassar Stats available through the following website: http://vassarstats.net/fisher2x3.html. Significance is indicated if $P < 0.05$.

Coding of the interviews

The automatically generated transcript of the interviews generated by Zoom (Zoom.com) was checked for accuracy by author O.J.P. Coding of the transcripts by Daria Cherepovitsky and authors O.J.P. and R.F. followed the same process described above.

RESULTS

Forty-two students consented to take part in this study. This represents a 44% participation rate.

RQ1. What impact does a podcast assignment have on students' knowledge of the COVID-19 vaccines?

Students self-selected COVID-19 misconceptions as topics for their podcasts (Table 1). Forty coded reflections written by students upon the completion of podcast assignment (post-podcast reflection) revealed the following themes: source of information, positive vaccine outcome, accurate information, awareness of spread of inaccurate information, vaccine concern, inaccurate information, strategies to promote vaccine acceptance, overall impression of podcast assignment (Table 2).

Thirty-seven students (92.5% of respondents) explicitly discussed positive vaccination outcomes, including promoting the health of themselves, family, and/or friends, a return to normalcy, and overcoming the burdens of the pandemic. Students also described the biology of the COVID-19 vaccines, COVID-19 illness manifestations, and the relationship between COVID-19 and politics. Over 87% of students recommended that improving access to, or finding data and research from credible sources, could reduce vaccine hesitancy. Furthermore, 20% of students felt that knowing others who had contracted COVID-19 would be enough of an incentive to overcome vaccine hesitancy. Of the

TABLE 2 Post-podcast reflection themes[a]

Category	Theme	Representative quote	Percentage of reflections (*n* = 40)
Source of information	Social media	"Some people do not want the vaccine because they believe in from some of the rumors circulating on social media."	40%
	Scientist	"Some great resources are public health experts (CDC, NIH, ADPH), scientific journals or scientists,"…	7.5%
	Family/friends	… "because of what they heard about vaccines growing up (that a piece of the virus was in the shot and some people would get sick from it)"...	5%
Positive vaccine outcome	Health of self/family/friends	…"get the vaccine in order to keep themselves from getting sick or transmitting the virus to others."	92.5%
	Return to normalcy	"As the world gets vaccinated the world will return to a new normal and less people will have their lives disrupted or even ended by COVID-19"...	80%
	Burdens of the pandemic	"Another reason to want to get the vaccine is that once you get it you can start doing more"...	40%
	Other advantages	"Some job opportunities also incentive getting the vaccine"...	20%
Accurate information	COVID-19 vaccine (vaccine names, contents, efficacy, side effects)	"The COVID-19 vaccinations are mRNA vaccines"	95%
	COVID-19 and/or general vaccine biology	"The mRNA vaccines are supposed to produce an immune response by transfecting synthetic RNA into immunity cells"...	40%
	COVID-19 illness (death/infection rate)	"The virus may not be that bad is so many people, but it cannot always be predicted if it will be severe, so people need to get the vaccine."	22.5%
	Politics/government (influence, reporting accuracy, infighting)	"Another thing that could cause a person to want the vaccine could be losing a loved one or someone close to them to COVID-19"...	17.5%
Awareness of spread of inaccurate information	COVID-19 vaccine (vaccine names, contents, efficacy, side effects)	"Some people are not getting the COVID 19 vaccine because there are myths and misconceptions going around our communities. These misconceptions include that the COVID 19 is not effective because it was rushed, if a person has contracted COVID 19 they should not be vaccinated, and that the COVID 19 vaccine can give them COVID 19. These misconceptions and myths cause vaccine hesitation in our communities."	87.5%
	Basic biology	"Some laymen don't even believe that COVID-19 exists"	37.5%
	Politics/government (influence, reporting accuracy, infighting)	"Some people also believe that it is a political issue and that getting a vaccine would go against their political views. While worst yet, some wish to misled and use others think that the virus won't get to them"…	25%
Vaccine concern	General side effects	…"there are a lot of serious side effects it can do to someone's body"	75%
	Research and/or production was rushed	…"this vaccine was produced way too fast"	50%
	Efficacy concerns	…"the vaccines haven't been tested enough to ensure the safety or the effectiveness"	45%
	Fertility side effects	…"it can cause infertility"	32.5%
	Personal autonomy	"People should be allowed to make their own decision about whether or not they want to take one of the vaccines"...	22.5%
	Minority healthcare concerns	"This tends to be fear of the healthcare system due to past mistreatment including the Tuskegee experiment preformed with the CDC."	15%
Inaccurate information	COVID-19 illness (death, infection rate, etc.)	"There is no need to get a vaccine for a virus that if you do get it you have a very high chance to survive, and since people are socially distancing and wearing masks there is no point"...	20%
Strategies to promote vaccine acceptance	Family impact (diagnosis of COVID-19 infection, or COVID-19 vaccine acceptance, family expertise)	"Another thing that could cause a person to want the vaccine could be losing a loved one or someone close to them to COVID-19"...	50%
	Improved access to data/research	"I think what could change the mind of those who do not want to get the COVID-19 vaccine is doing research from credible resources"...	37.5%

(*Continued on next page*)

TABLE 2 Post-podcast reflection themes[a] (*Continued*)

Category	Theme	Representative quote	Percentage of reflections (*n* = 40)
	Improved resources for minorities (translators, access, acknowledgment of historical abuses and strategies to prevent recurrences)	"Most low-income families work all the time and do not get paid sick leave even if it is from the vaccine."	17.5%

[a]Forty students completed post podcast reflections. Subthemes that were present in over 50% of the reflections are highlighted in gray. The representative quotes come directly from the student reflections unedited and, therefore, may include writing errors.

sub-set of students who directly mentioned the podcast activity in their reflections (14 of 40 or 35% of respondents), 82% indicated they learned more about COVID-19 vaccines or were positively influenced to get the vaccine, whereas 18% of these respondents said the module did not impact their knowledge or opinions.

Sixteen students (40% of respondents) reported getting most of their information from social media, such as this student who wrote:

> "Another way the medical community is already getting people to get the vaccine is through advertisement campaigns. Countless advertisements have been put out and convinced me and many of my other peers to get it, so they are effective. Another campaign is how people post getting the vaccine and asking them to post it to their story, Instagram, or social media to spread the word that they got the vaccine. This would get many people to do it because it shows that many people have gotten the vaccine, and there are not many negative side effects that should deter them from this vaccine."

Nearly all students (87.5% of respondents) discussed the spread of inaccurate information, with 8 students (20% of respondents) themselves describing COVID-19 or its vaccines inaccurately (based on the knowledge disseminated in the expert guest lectures).

The majority of students expressed at least one concern regarding the vaccines including students who reported already being vaccinated. These concerns related to general side effects, the impression that the vaccine research and/or production was rushed, the vaccine's effectiveness, fertility side effects, personal autonomy, and minority healthcare. For example, 1 of the 30 students who reflected on vaccine side effect concerns stated:

> "Even though I have already taken one dosage of the vaccine already, I am nervous about side effects as I have a more compromised immune system."

RQ2. What impact does an active learning podcast assignment have on students' impression of the COVID-19 vaccines?

The pre-podcast reflections were coded to reveal the student's general impression of the COVID-19 vaccines to be positive (37.5% of students), neutral (55% of students), or negative (7.5% of students). We determined that this impression shifted significantly after completing the podcast assignment, such that 87.5% of students had a positive impression of the COVID-19 vaccines, with 10% of students reporting a neutral impression and only 2.5% maintaining a negative impression of the vaccine (Fig. 1A). Within this shift, 55% of students' impression of the COVID-19 vaccines were improved; while 42.5% remained unchanged and 2.5% of student's impression of the vaccines worsened between these two reflections (Fig. 1).

> Before this group project, I did not know much about COVID-19. I would occasionally see big headlines about it, but I never took the time to look into it. As far as vaccines, I was hesitant to get the vaccine. Like most that are hesitant, I was worried about the side effects, even though I was not

> sure what they were. I was also worried that the vaccine would not work. However, this project has changed my perspective on the vaccine. … As far as recommending the vaccine, I would say that I do recommend getting it now. However, I would say to get the Pfizer or Moderna vaccine instead of the Johnson and Johnson.

The Fisher Exact Test indicates that completion of the podcast assignment is significantly associated with an improved impression of the COVID-19 vaccines (P_A = 0.000005; P_B = 0.000004)

The post-podcast reflections also identified 14 students with broadly positive impressions of podcasts as an assignment and 3 students that had broadly negative impressions of the podcast assignment (Fig. 1).

One-on-one interviews with the students after the submission of the post-podcast reflection revealed five major themes related to the podcast. The project allowed students to (i) do more research on the COVID-19 vaccine, (ii) improve their science communication skills, (iii) inform others about the COVID-19 vaccines, (iv) address COVID-19 vaccine misinformation, and (v) understand different perspectives (Table 3). Five of the seven interviewees who discussed the podcast activity explicitly mentioned that the project prompted them to do more research on COVID-19 vaccines and left them feeling more confident in their science communication skills, as they informed others about the COVID-19 vaccine. Four of the interviewees explicitly stated that the podcast project accomplished its learning objective as their podcast sought to debunk certain misinformation they heard before the assignment. Unexpectedly, three of the interviewed students revealed that the assignment improved their understanding of different perspectives.

DISCUSSION

While podcast usage has seen a dramatic increase from 9% of Americans over 12 years old in 2008, to 41% in 2021 (63), its impact in university classrooms, particularly non-major classrooms, is lacking. In this study, students created podcasts related to COVID-19 vaccine misconceptions they were aware of. This assignment was in alignment with the course learning objectives: (i) understand the basic process of science and identify the valid sources of scientific literature and (ii) understand the biological basis of COVID-19 vaccination in the context of immunology and human physiology. Our previous study on this same cohort of students demonstrated that expert-led guest lectures influenced students' willingness to receive COVID-19 vaccines (34). However, our previous work was pedagogically limited in that the intervention on its own was not student-centered. Moreover, by focusing strictly on decision-making around vaccines as being safe and effective, as well as the student vaccination status, our previous work did not ascertain students' direct knowledge, or impressions of the COVID-19 vaccines. Here, we explore

TABLE 3 Interview codes[a]

Theme	% of interviews (n = 7)
Assignment allowed students to do more research on the COVID-19 vaccine	71%
Assignment improved students' science communication skills	71%
Students informed others about the COVID-19 vaccine	71%
Podcast topic was a COVID-19 related misinformation that they heard before the assignment	57%
Assignment improved students' understanding of different perspectives	42%

[a]Seven students participated in interviews. Themes that were present in over 50% of the reflections are highlighted in gray.

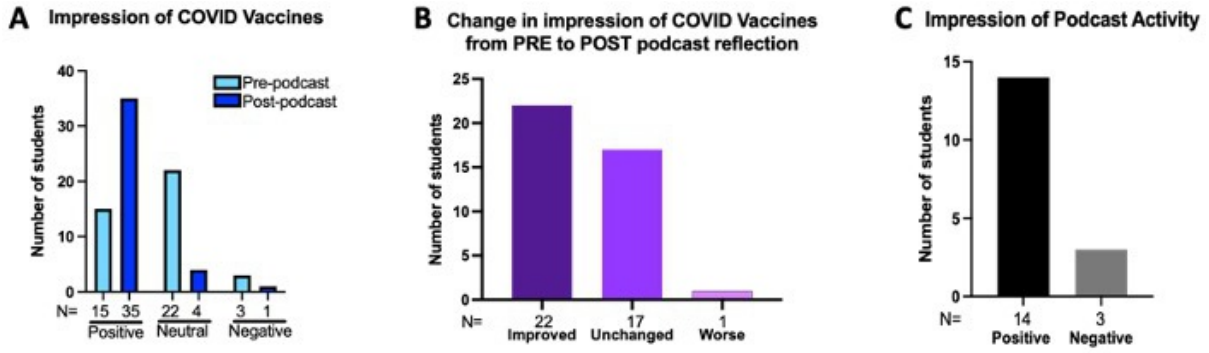

FIG 1 Impact of podcast activity. Forty students completed both the pre and post-podcast reflections. (A) Students' general impression of the COVID-19 vaccines as positive, neutral, or negative in the pre-podcast reflections (light blue) and post-podcast reflections (dark blue). (B) Number of students whose impression of the COVID-19 vaccine improved (dark purple), remained unchanged (intermediate purple), or worsened (light purple) from the pre- and post-podcast module. (C) Students' general impression of the podcast activity as either positive (black) or negative (grey) in the post-podcast reflections.

how students creating their own podcasts impacts their learning gains and overall impression of COVID-19 vaccines.

What impact does a podcast assignment have on students' knowledge of the COVID-19 vaccines and why people do or do not want to receive a COVID-19 vaccine?

Mindful of the process of backward design (64), the learning goals of the podcast assignment were aligned with the course learning objectives. Relevant to our first learning objective, all students cited valid literature to dispute the COVID-19 vaccine misconceptions their podcast addressed. Additionally, 97.5% of student respondents stated accurate information about the COVID-19 vaccines during their post-reflection (Table 2). Related to our second learning objective, students were able to discuss accurate information regarding the SARS-CoV2 virus, vaccines' contents, side effects and vaccine biology, as well as SARS-CoV-2infection and mortality rates (Table 2). This reflects the content included within our course module in addition to information students explored independently within or beyond the podcast assignment.

Our findings also indicate that at the end of the project, while the students reported ongoing concerns about the COVID-19 vaccines, these concerns no longer included the misconception the student addressed in their podcast. The remaining misconceptions were broad, including side effects, vaccine development timeline, and ethical considerations. These concerns are in line with previous research demonstrating the concerns of our students mirror those of the public (65). While the podcast assignment was set up for students to address one misconception of their choice, it was not set up to be able for students to unpack all the information circulating during the Spring of 2020. Regardless, the reflection prompts surrounding this assignment gave the students a forum to express genuine concerns they had with regard to the COVID-19 vaccines (Table 2). During their interviews, students expressed that completing this assignment also helped them understand different perspectives regarding the COVID-19 vaccines (Table 3) as well as improving their science communication skills (Table 3).

Only 4 students (10% of respondents) referenced having a scientist or healthcare professional as their source of information, while 22 students (55% of respondents) discussed social media, family, and friends as their information source regarding the COVID-19 vaccine (Table 2). Moreover, 71% of interviewed participants appreciated that the assignment drove them to deeply consider the source of information (Table 3). Our findings partially align with a larger study which found that of their 18- to 39-year-old cohort, 13% reported their doctor or medical provider is their primary source of COVID-19 information (66). However, in that study, only 30% of 18- to 39-year-old respondents reported "new media" which included social media, and family and friends

as their primary sources of COVID-19 information (66). The impact of traditional and non-traditional sources of COVID-19 information was clear within the United States (66, 67) and abroad (68, 69). Given their information source, we would expect the students to retain concerns and inaccurate information. This emphasizes the importance of education geared toward improving scientific literacy and especially, information source evaluation. Furthermore, these responses highlighted the weight that social media and personal relations carry as information sources. For our students, 45% referenced those information sources, and half of our students went on to recommend the COVID-19 vaccine to others, stressing the impact of COVID-19 on families as an effective strategy to improve vaccine acceptance (Table 2).

In coding the reflections, a further nuance of student learning was identified. Regarding their overall impression of the podcast as an assignment, 14 of the 40 students reflected positively on the podcast as an interesting way to guide the students to explore the topic. Only three students made comments indicating a negative impression of the assignment, so beyond those three all other comments indicated the assignment was well-received. Further exploration is needed into the impact of students' impression of an assignment and their learning outcomes.

What impact does an active learning podcast assignment have on students' impression of the COVID-19 vaccines?

While student learning is an expected gain from a curriculum, we did not know the degree to which this learning would impact students' overall impression of COVID-19 vaccines particularly as it related to misconceptions. We have demonstrated that prior to this podcast assignment that a majority of students perceived the COVID-19 vaccines as safe and effective (20), but this previous work fell short of understanding how students having ownership over their own vaccine literacy impacts their impression of COVID-19. After this podcast assignment, there was still a significant shift in the overall impression of the COVID-19 vaccine from neutral to positive (Fig. 1), and the impression of the COVID-19 vaccines improved for over half of the students (Fig. 1). However, despite improving overall impression and students addressing nationally recognized misconceptions (65), nearly all of the respondents continued to express at least one concern regarding the COVID-19 vaccines after the podcast project was completed (Table 2). While 57% of interviewed students specifically discussed that they selected the topic of their podcast to explore something that they had heard (Table 3), 20% of students in this study Fig. 1 continued to mention factually inaccurate information in their responses to the post-reflections all while significantly improving their overall impression of the COVID-19 vaccines (Fig. 1). Together, this indicates that while the vaccine awareness module was successful in improving student impression of the vaccine, there were still areas where students' concerns were not completely assuaged.

In their post-reflections, 92.5% of the students had a positive or neutral impression of the podcast assignment (Fig. 1) which required students to communicate vaccine science related to misconceptions. In other words, as little as 7.5% of students had a negative impression of the podcast assignment (Fig. 1). By virtue of the module focusing on podcasting, students were making these associations while also practicing science communication skills could have contributed to students having positive or neutral impressions of the podcast assignment. With 48% of Americans reporting that they believe they have come across COVID-19 misinformation (65), we suspect that the confluence of these skills enabled non-majors to more critically evaluate the information they encounter outside the classroom. Interestingly, while science communication does not always result in improved science literacy, science communication can act as a conduit for improved interest in, or change of, attitude towards science (70, 71). While beyond the scope of this study, understanding how non-majors continue to evaluate and curate scientific knowledge is an important next step in understanding broader vaccine impressions. Moreover, better understanding the reasons for their positions on vaccine

acceptance such as cultural norms and political leanings could help us see non-majors and all university students as a heterogenous group with diverse schools of thought (72).

A majority (3 of 5) of the themes from the interviews (Table 3) reference students being engaged in science communication. Like previous work (72, 73), our data demonstrated that, even with minimal science communication training, assignments like podcast creation improves student knowledge and impression of COVID-19 vaccinations. While it has long been recognized that science communication needs to be improved (74–76), during the COVID-19 pandemic, rampant misinformation made the value of effective science communication incontrovertible. Future work could put students' science communication to the test by exploring knowledge and affectual outcomes of the audience of student-created podcasts, be it student's circle of influence (72), or the members of the general public. While our education model focused on an emphasis of facts, non-majors could be taught how to address misconceptions through more emotional and cognitive means (77) and teach their networks to be attuened to accuracy cues even in online formats (78). Non-major student knowledge can be a fulcrum between university education and diverse communities.

Outlook

More than ever before, the COVID-19 pandemic has required non-scientists and non-healthcare workers to make wide-reaching decisions regarding COVID-19. The reflections and interviews here have highlighted the sizable impact that non-scientists are having in these discussions. Therefore, having non-scientists able to recognize reputable sources and trained to (i) seek information from reputable sources and (ii) discuss science topics respectfully with others who have different perspectives is vital. For this reason, deploying this intervention in a non-majors, class was a particularly important strength of this project. Our study supports the notion that having the opportunity to practice communicating in a field that is not their intended field of expertise improves students' confidence in science communication and empathy for other perspectives.

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DATA AVAILABILITY

Data are available upon request.

ETHICS APPROVAL

This research study was approved by The University of Alabama at Birmingham IRB, protocol number IRB-300006871.

ADDITIONAL FILES

The following material is available online.

Supplemental Material

Supplemental_Material_SR (jmbe00034-23-S0001.pdf). Supplemental Table S1 (Demographic description of participants).

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