Self-Study of a Project-Based Graduate Science Communication Course Focused on Electronic Field Trip Development

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Abstract

The increasing importance of science communication demands college curricula to respond with innovative teaching methods. Land-grant universities are uniquely positioned to engage students and scientists in dynamic science communication courses with intentional project-based learning (PjBL) design approaches. Electronic field trips (EFTs) can be leveraged as a focused project within PjBL to foster science communication through scientist-student partnerships. EFTs are becoming increasingly popular, as resources for physical field trips decrease. The purpose of this self-study was to examine a graduate-level PjBL course at the University of Florida that guided students to develop an EFT about bats in partnership with Florida Museum of Natural History mammalogists for middle and high school youth. Concepts from digital literacy guided this research to enhance students' multimedia science communication skills. The study aimed to determine the students' and scientists' experiences participating in an EFT and their recommendations for making improvements. Co-constructed interviews and focus group methods provided insight into the students' and scientists' learning and perspectives. Students reported a gain in digital literacy, science communication skills, and environmental engagement. Scientists gained experience with communicating to a youth audience in a new way. Students and scientists also discussed the challenges of communicating via EFTs and recommended expanding the experience.

Introduction

Science communication is more important today than ever before, due to the unlimited options for information sources that are often based in opinion and emotion, rather than science and research (National Academies of Sciences, Engineering, Medicine [NASEM], 2017). It is imperative that the public engages in science communication processes to develop a science-based understanding of climate change, growing a secure food supply, and other quality of life advancements (Nisbet & Scheufele, 2009). Conversely, scientists are called upon to transparently communicate their work in engaging formats to increase public science literacy (NASEM, 2017). Scientists are often said to lack the skills needed to communicate scientific concepts with terms and examples the general public will understand (NASEM, 2017). Meanwhile, collaborations are increasing between science communication researchers and scientists to grow intentional public science engagement and outreach efforts (American Association for the Advancement of Science, n.d.). In response to the growing science communication and engagement momentum, there is a need to develop higher education courses with active learning approaches that promote science communication interactions between students and scientists through real-world, innovative, project-based work that will prepare the participants for 21st-century careers. The following study examines student and scientist experiences within a college course intentionally designed with such goals.

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Science Communication College Course Design for Active Learning and Extension

There is a need for novice communicators and scientists to participate in innovative real-world experiences for fostering science communication skill development. A portion of the training should include a focus on how to identify and examine target audiences as a key component of the communication process (Bray et al., 2012). Bray et al. (2012) identified storytelling as a communication approach that could connect science communicators with audiences on a personal and relational level that promotes trust in the message. Audience groups could include but are not limited to youth, parents, generational groups, gender groups, groups determined by race, occupational groups, and groups based on educational level. Science communication with the public is said to be effective when the science communicator values and understands different "knowledge, values, perspectives, and goals" of their audience (Nisbet & Scheufele, 2009; p. 1777).

The land-grant university mission and establishment of the Cooperative Extension Service serve as a link between scientists and the public. Land-grant universities were established to provide a practical, liberal education to those interested in gaining knowledge around agriculture, military tactics, and mechanics (Association of Public Land-Grant Universities [APLU], n.d.; Rasmussen, 1989; Seevers & Graham, 2012). The mission of the land-grant university is to provide educational knowledge, conduct research, and extend that knowledge from research to the people in communities across the state (APLU, n.d.; Rasmussen, 1989; Seevers & Graham, 2012).

Graduate-level college communication courses at land-grant universities can be leveraged to prepare students to become communication professionals. Such courses can be designed to develop different capacities, such as communication skills, communication skills with theoretical principles, and the understanding of science (Turney, 1994). Bray et al. (2012) conducted a study to qualitatively understand science, education, and science communication experts' perceived essential elements of a science communication course that resulted in the recommendation for courses to focus on science, communication, and social theory. Turney (1994) indicated that communication curriculum should include the opportunity for students to do communication and practice the different capacities being developed through courses. The American Association of Agricultural Education's research agenda similarly calls for an evolution of current teaching practices to incorporate innovative active learning approaches and technologies to create a meaningful, engaging learning environment (Edgar et al., 2016).

Project-based learning (PjBL) is an active learning, instructional design model that could be applied to college science communication courses for innovative, immersive teaching and learning. PjBL facilitates a space for students to gain knowledge through developing a project related to a complex problem or issue, using critical thinking, creative, and communicative abilities (Buck Institute for Education [BIE], 2019). PjBL is rooted in the active and democratic learning philosophy, first developed by John Dewey and William Heard Kilpatrick (Peterson, 2012). Loizzo & Lillard (2015) conducted a study that explained undergraduate student experiences in a PjBL course at Purdue University. Through this course, students worked alongside Extension professionals to develop online, educational videos for lay audiences about smallholder farming (Loizzo & Lillard, 2015). Undergraduate students had an increased awareness of Extension, an increased knowledge of small farms, and skill development in the areas of project management, video production, and practical application, as a result of participation in the PjBL course (Loizzo & Lillard, 2015). To engage the science communication graduate students in real-world PjBL in this study, an electronic field trip was chosen to serve as the central project for students to develop as an intentional way to encourage critical thinking, development of multimedia skills, and awareness of current scientific research.

Electronic Field Trips for Science Communication and Engagement

Science communication and education can be achieved in various ways, including field trips. Field trip experiences are informal science education events that have the potential to encourage students to develop positive attitudes toward STEM (science, technology, engineering, and math) subjects, as well as retain science-based information by connecting the information with the sensations of the experience (Knapp, 2010; Rudmann, 1994). While physical field trips are ideal for first-person learning, they are not always possible due to constraining logistics (Cassady et al., 2008).

With decreased funding allocated for school field trip expenses, there is a growing need for alternative experiences for students to learn interactively (Greene et al., 2014). Electronic field trips (EFTs) have increased in popularity as an educational technology that allows students to virtually and vicariously participate in field trip experiences that they might otherwise not be able to have (Cassady et al., 2008; Stoddard, 2009). Participation in EFTs has not shown a decrease in educational value, as compared to physical field trips (Garner, 2004; Tuthill & Klemm, 2002). Instead, research has shown participation in EFTs has increased students' engagement in science and critical thinking abilities (Adedokun et al., 2011; Sriarunrasmee et al., 2015). The EFT project in this study required graduate students to consume digital content, as well as create online content through the application of digital skills. The following section outlines the broader concept of digital literacy and its connection to this research.

Conceptual Framework

Broadly, digital literacy served as the conceptual framework that guided this study. Through the lens of digital literacy, the authors examined a graduate-level PjBL-

designed university science communication course with a central focus on EFT development and implementation for increasing students' science communication knowledge and skills.

Digital Literacy

Digital literacy is similar to the idea of general literacy in terms of the ability to read, comprehend, and write. However, digital literacy takes those skills a step further to introduce technology (Heitin, 2016; Lynch, 2017). Digital literacy is the ability to locate, comprehend, and synthesize information in a digital space to then be able to digitally create content and communicate the information electronically (Heitin, 2016; Lynch, 2017). Whereas being literate by having the ability to read and write was a job requirement in the past, the current state of technology and the need for digital skills is quickly demanding digital literacy as basic job requirements (Griffin et al., 2012; Lynch, 2017).

Due to the large demand for digital literacy, there has been a large push in primary and secondary education to integrate digital learning into everyday curriculum (Griffin et al., 2012; US Digital Literacy, n.d.). The Assessment and Teaching of 21st Century Skills (ATC21S) project has outlined skills that students in a 21st-century primary education should be fluent in to meet the demands of the world around them (Griffin et al., 2012). Conceptually, ATC21S outlined four broad categories (i.e., ways of thinking, ways of working, tools for working, and skills for living in the world) that students should practice through collaborative problem solving and information communication technology (ICT) literacy (Binkley et al., 2012; Griffin et al., 2012).

Integrating digital literacy into curriculum at the post-secondary and university levels has become as important as digital literacy integration at the primary and secondary education levels. Johnson et al., (2016) identified three different components of digital literacy that are critical for those pursuing higher education, including: (a) universal literacy – the ability to use basic digital medias for locating information and office work, (b) creative literacy - more advanced digital skills to produce digital content such as video, audio, and animation, and (c) cross-disciplinary literacy - integration of digital literacy across different courses, departments, and colleges. Digital literacy across disciplines is often the component least exercised because it often requires a redesign of the curriculum (Johnson et al., 2016).

Stockton University in New Jersey integrated digital literacy in the classroom by offering a minor in digital literacy and multimedia design that requires several technical, theoretical, and applied courses that facilitate a space for students to gain technology skills and digital theoretical foundations (Stockton University, n.d.). The University of Houston's College of Education has emphasized digital storytelling in their curriculum and evaluated their courses based on the ADDIE (i.e., analyze, design, development, implementation, and evaluation) model to provide recommendations for other university faculty interested in incorporating digital storytelling into their courses (Robin & McNeil, 2012). Peterson (2013) evaluated the use of integrated technology in the college classrooms of English teachers at an Iowa community college. The NMC Horizon Report indicated short-term mobile apps and tablet computing will be beneficial to the college or university classroom and game-based learning tools and learning analytics will be beneficial medium-term (Peterson, 2013).

Johnson et al. (2016) provided recommendations to assist colleges and universities in entering the digital literacy landscape, such as (a) engage in strategic implementations and level-up current digital literacy curricular efforts, (b) focus on students as content makers, not simply content consumers, and (c) build industry-education partnerships to build suitable digital workspaces that facilitate learning. The following study applied these recommendations by engaging graduate students in digital literacy skill development inside and outside of the classroom, as they created and researched an EFT for middle and high school youth through collaborations with the Florida Museum of Natural History. The purpose of this study was to examine student and scientist experiences within the context of a PjBL course focused on EFT development and implementation, as well as their recommendations for future iterations of the course and EFTs. Research questions included:

RQ 1: What are graduate students' experiences participating in a PjBL-designed course focused on EFT production?

RQ 2: What are scientists' experiences participating in an EFT focused on their wildlife and climate change research?

RQ 3: What recommendations do graduate students and scientists have for improving future iterations of the PjBL course and Streaming Science EFTs?

Methods

Course Design

The authors conducted a self-study of the AEC 5541: Instructional and Communication Technologies in Agriculture and Natural Resources course with the accompanying course project, the Streaming Science: Bats and Beyond electronic field trip, using multiple qualitative methods. The lead author developed and taught the course at the graduate level in the Agricultural Education and Communication Department at the University of Florida during the fall 2018 semester. Eight graduate students enrolled in the course and were assigned to design and deliver an EFT around the topic of bats with Florida Museum of Natural History mammalogists. The instructor and students met face-to-face once a week for approximately three hours and participated in readings, assignments, and various EFT creation steps online and outside the classroom.

EFT Design

The class implemented the live web-casted EFT on November 15, 2018, at the University of Florida Bat Houses, located on the university campus (Figure 1).

Figure 1. Graduate students and mammalogists rehearse for 'Bats and Beyond' EFT.

Students chose to title the program 'Bats and Beyond,' and the program included three segments: (a) overview of bats, bat houses, and mammalogy careers, (b) an inside look at the university museum's bat collections, (c) the mammalogists' bat genetics research being done in The Bahamas. The students developed the EFT for the Streaming Science platform. Streaming Science is a student-driven platform that features student-developed multimedia and science communication projects often created in the lead researcher's PjBL designed courses. The lead author founded Streaming Science in 2016 at the University of Nebraska-Lincoln. The Streaming Science EFT model (Loizzo et al., 2019) includes the use of a wifi hotspot, iPads with video/audio hardware accessories, and software applications, to produce and deliver a live, interactive 45-minute webcast from a field location to schools via a streaming website. Researchers selected the live, interactive webcast format to simulate the benefits of traditional school field trips via vicarious online learning. A recording of the live program was posted to the Streaming Science website for schools to use asynchronously at later dates.

The graduate students and scientists hosted two, live EFT sessions (2:00 p.m. and 4:00 p.m. EST). The program was free and open to all middle and high school science and agriculture classes around the world. The program was predominantly advertised in Florida, as well as the home states of the participating graduate students, and via the Streaming Science social media channels. Schools registered to participate via a provided web link. Approximately 11 middle and high schools, 330 students, and 11 teachers viewed the live EFT. Participating viewers were located across the United States (i.e., Florida, Oklahoma, Texas, Louisiana, Colorado, New Mexico, and Maine) and in Trinidad and Tobago. Three mammalogists from the Florida Museum of National History hosted the EFT in addition to the graduate students.

Data Collection

The eight graduate students participated in video-recorded, co-constructed, face-to-face interviews in groups of two during a scheduled class period following the EFT. The students developed interview questions in pairs and

Table 1: Description of Study Participants

Pseudonym	Background	Degree/Specialization	Data Collection
Velma	Doctoral Student	Ag & Biological Engineering	Both
Jared	Doctoral Student	Ag Education & Communication/ Ag Communication	Both
Allison	Doctoral Student	Ag Education & Communication/ Ag Communication	Both
Christine	Master's Student	Ag Education & Communication/ Ag Communication	Both
Sydney	Master's Student	Ag Education & Communication/ Ag Communication	Both
Yasmin	Master's Student	Ag Education & Communication/ Ag Leadership	Both
Brad	Master's Student	Ag Education & Communication/ Ag Leadership	Both
Lauren	Master's Student	Ag Education & Communication/ Ag Leadership	Both
Steven	Mammologist	Curator of Mammals	Focus Group
Amity	Mammologist	Mammals Collection Manager	Focus Group
Ashley	Mammologist	Mammals Grad Student	Focus Group

interviewed one another based on their co-developed interview guide. The interviews ranged from five to ten minutes in length per person. The interview guides were co-constructed within each group to reduce the possibility of the instructor developing biased questions. Additionally, the lead researcher/course instructor led and moderated a focus group with the graduate students and the scientists during a scheduled class period after the interviews. The graduate students and the course instructor collaborated to develop a moderator's guide for the focus group. Table 1 outlines the interview and focus group participants.

All participants voluntarily consented to participate and selected their pseudonyms for reporting results. The participating graduate students' grades in the course were not impacted by their participation in the research. The University of Florida Institutional Review Board of human subjects research approved this study.

Data Analysis

The second author transcribed verbatim the four sets of interviews and the focus group. Both authors individually openly coded the transcripts using Dedoose, a qualitative analysis software. The authors then compared codes and chunked them into agreed-upon categories. The following categories were determined: student experience, scientist experience, and recommendations. The final themes emerged from the categories. The authors then sent a draft of the results to all of the participants for member checking to ensure the themes correctly reflected their thoughts and perceptions (Ary et al., 2014; Creswell & Cresswell, 2018).

Reflexivity

The course instructor was the focus group moderator and the lead researcher for this study. The course instructor/focus group moderator/lead researcher has been an assistant professor for four years, has doctoral and master's degrees in learning design and technology, a bachelor's degree in radio-television, previously worked in the broadcast industry, and has worked on EFTs in various formats since 2007. Previous Streaming Science EFTs included 'Ranches, Rivers, and Rats' and 'Sun Rays and Windy Days', both EFTs were unrelated to bats. The previous EFTs were hosted in the state of Nebraska, whereas the Bats and Beyond EFT was hosted in the state of Florida. Before the EFT, the course instructor/focus group moderator/lead researcher had little to no level of knowledge pertaining to bats.

The second author for this study is a graduate student in the Agricultural Education and Communication Department studying agricultural communication at the University of Florida. She did not participate in the course, interviews, or the focus groups to any degree. This researcher had little to no knowledge of bats and EFTs before this research study.

Results

This study presents detailed examples and quotes from participating graduate students' co-constructed interviews and the focus group which included students, scientists, and the instructor. A theme for each research question emerged and is outlined in the following sub-sections.

The EFT project served as a context and vehicle to support graduate students' growth in science communication skills, EFT knowledge, and wildlife empathy. (RQ 1)

Graduate student participants discussed a variety of intrinsic and extrinsic motivations for enrolling in the course. Three of the agricultural education and communication students are in the agricultural leadership specialization. These three students took the course as a requirement for their plan of study (extrinsic) and aimed to potentially apply their learning about instructional and communication technologies within the course to their teaching and research interests (intrinsic). Four of the agricultural education and communication students are in the agricultural communication specialization. These four students took the course as a requirement (extrinsic), yet they also placed an emphasis on personal goals of further development of their online communication skills for future careers (intrinsic). Christine said:

> I would really like to be a social media director or marketing director for a company one day, specifically a non-profit, and I know that these skills are tangible and really needed. So, I figured this would be a great course to start out with to really learn more about video and communication science – which is something that I am passionate about.

Only one student came from outside of the agricultural education and communication department. Velma was a hard sciences student in the area of agricultural and biological engineering with a research emphasis on sustainable food packaging practices. She specifically sought out the course and enrolled with an intrinsic motivation to increase her science communication skills and apply her new knowledge to her future career as a scientist. Yasmin and Velma discussed Velma's motivations and experience in the course and with the EFT in their co-constructed interview. Velma said:

> Prior to this EFT, some of the ways I thought about communicating science to others were basically through my research, but I hadn't thought about it in the non-formal/informal aspects that we have approached in this particular course. More so, I have done that through publications, manuscripts, and things like that, but not exactly to study your audience, know what they would want to hear, what they would be perceptive. So, this was a very

> new experience for me actually studying how to communicate science versus just how to perfect science. That's a very different contrast for me.

As demonstrated by Velma's interview, the students had varying levels of science and multimedia production skills and prior knowledge. Some of the participants such as Jared and Yasmin had experience in previous undergraduate courses, internships, and jobs with developing online videos for a variety of audiences. Christine, Sydney, and Allison had some moderate video experience, while others such as Brad, Lauren, and Velma had limited expertise in multimedia development. Lauren described, "In high school I did a lot with photography, but it was a lot of still photography and still with film." She built upon her prior experience, updated her knowledge, and expanded her skills and confidence in media production through participating in using the mobile gear to produce the EFT. She said, "I learned that it's not as difficult as I thought. So, that's helpful, and I didn't break anything [the equipment], but I had very little knowledge on media production, how to splice videos - none of that."

Students organized into teams and roles for EFT production for the voice and choice portion of PjBL and with the instructor's support. Table 2 outlines the student teams and responsibilities.

Students, such as Yasmin and Jared, with higher levels of video production backgrounds, gravitated toward the roles of video editors for pre-production work. However, these students took the time to mentor and engage students with less experience through the process of preparing the videos and utilizing the video-streaming mobile application. While Jared did have a high degree of video experience and helped many of his classmates with the hardware and software, he did appear to value continuing to grow his communication skills. While also learning about instructional design in the EFT project context, he said:

> There is so much that that we need to do in terms of communicating the right message and sharing knowledge with people, in order for them to understand it. Using technology is a great way to translate science-based information - putting it into the hands of viewers and listeners and the general public.

Lauren discussed how she learned from others such as Jared:

> I kind of paid attention to what my other classmates were doing and seeing, their interpretations of what an electronic field trip would be and then, I also tried to put my own spin on things - on what I would want to see if I was a student engaged [watching the EFT].

All of the students stated that they did not know what an EFT was, before participating in the class. Sydney said:

> Whenever we got our syllabus, and that was something [the EFT project] on the first line. I immediately thought back to my hometown and thought how incredible of an opportunity this would be for a low socioeconomic area like [hometown]. I just learned so much uh…over this semester about the endless opportunities for those areas and to make it a fair playing field for all classes and all school districts. An electronic field trip allows all areas and schools and districts to learn and to be involved in outside classroom learning, while still being in the classroom and without spending additional funding. It lets students interact with scientists like our EFT did. It allows them to see places that they wouldn't have the opportunity to see, without it being digitized.

Table 2: Student roles and responsibilities for EFT preparation.

Team Focus	Members	Responsibilities
School engagement and recruitment	Allison Velma Sydney Christine Jared	Teacher's Guide; Wrap-around materials; Social media posts; Mail Chimp emails; and Registration
Assessment	Brad Jared	Pre and post survey questions; Qualtrics formatting; and Paper-based formatting
Video pre-production	Allison Jasmin Jared Brad Sydney Christine Velma	Recording new videos; Capturing new photos; Collaborating with scientists' for existing footage/photos; Editing videos and photos; and Prepping iPads

Similarly, Christine outlined the benefits of conducting EFTs and the possible application of EFTs. She also considered how she might leverage EFTs in her future career. She said:

> Specifically, I would really like to work at a museum or an aquarium one day, and I think that learning about these EFTs will directly help me get a job one day at a museum at an aquarium because I can say, 'Hey, this is something that I know how to do. I have done it before, and it will be a great income for the museum or aquarium – and it is also a great way to get the museum or aquarium's name out in the public.'

Participation in the EFT overall appeared to raise students' awareness about alternative means for science communication, engagement, and outreach beyond typical channels such as press releases, blogs, and social media. Additionally, from her hard science perspective, Velma discussed that EFTs could help her with including broader impacts efforts on her curriculum vitae and to demonstrate to future employers and funders that she knows how to disseminate her research to a variety of audiences.

The focus of the EFT was on bats, the bat houses, and participating mammalogists' research tracking bat population movements in relation to sea-level changes over time. Throughout the course, the graduate students learned about bats, theories of wildlife empathy, visited the university museum's bat collections, and edited photos and videos the participating scientists' supplied of their fieldwork collecting bat genetic samples. Yasmin described that she had learned about bats before, but the class expanded that learning. She said:

> I have seen bats throughout my travels, and I think that they are adorable. I had been exposed to some bats in going to rain forests and being outdoors and in national parks, but I learned a lot from our three scientists that we had talking to us, and they taught me a lot about archives, collections, data, etc.- things like that that I wouldn't really have considered before. So, I did learn a lot.

Most of the other students said they did not have much prior knowledge of bats and that the EFT increased their appreciation of the creatures. Sydney discussed:

> I can confidently say that bats were not something that I was excited to learn about, once I had found out that we were doing an electronic field trip over them. I stereotypically thought they rabies and they could bite you and they were scary and not useful. After the electronic field trip, I saw all of those myths debunked and realized how important they are to our environment, how important they are to our climate, that they don't eat humans, don't bite humans, and I have a completely different perspective bats.

Christine discussed that she generally does not like most animals, except for dogs and cows. However, she kept an open mind throughout the course and even touched one of the bat specimens in the museum collections. She said:

> I appreciate them [bats] more on a scientific level, and I further know that they are important for climate change and important for measuring what is happening to our environment, and that bats can be researched for positive impacts on the world.

Beyond communication skill development and EFT awareness, these examples of discussion points that emerged about bats in the students' co-constructed interviews indicate a secondary outcome of the EFT PjBL approach. Students described attitude shifts toward wildlife and understood scientific concepts related to bat population genetics and climate change as a result of their time working with scientists and creating related content and multimedia for the EFT.

Scientists appreciated the EFT production process and online interactivity with PK-12 students about their research, yet mobile technology has some constraints for engagement. (RQ 2)

The three scientists who participated in the EFT and this study included the museum's curator of mammals (Steven), mammals collections manager (Amity), and their mammals graduate student (Ashley) from the Florida Museum of Natural History. When the lead researcher reached out to Steven with the idea of a live EFT from the bat houses on the university's campus, he and his research team volunteered to participate. Steven described that he previously taught a graduate-level course about broader impacts for research, based on the National Science Foundation's (NSF) model, and that the EFT could be an example for his students of public science engagement and outreach. The scientists appeared to share and value sharing their passion for mammals and research with a variety of audiences. Ashley said, "I am always game for getting in front of school kids to talk about bats."

In the focus group, the scientists discussed that they did not fully understand what exactly they had signed up for in the beginning:

> Amity:I think there was a little confusion on our part in the beginning. Like, what are we doing? What is this going to take? We didn't know what the time involvement was necessarily going to be in the beginning when we first got the email. And, walking in on the first day of class we were like I still don't quite know what we are doing but then it became clear and it worked out okay.
>
> Steven: I felt a little bit the same way, but I was down for whatever we were going to do.

The scientists' participation included (a) a meeting with the class early in the semester (all three scientists), (b)

sharing field photos and video footage (Ashley), (c) guiding a class tour of the mammal collections (Amity), (d) a lab video shoot (Ashley), (e) a two-hour rehearsal the day before streaming live (all three scientists), (f) a half-day for the live program (all three scientists), and (g) a one-hour meeting for the follow-up focus group at the end of the semester (all three scientists). Steven discussed that for faculty members on nine-month appointments, the time commitment may be too much. However, he said for museum-affiliated faculty on 12-month appointments with supporting personnel and graduate students, the time commitment is appropriate. Ashley agreed that splitting up the participation among a team of scientists made the time commitment manageable. Steven offered to speak to future scientists who may want to participate in the EFTs about the value of their participation and balancing the time commitment.

The scientists noted an appreciation for the graduate students' participation in science communication, as well as, their facilitation and learning to produce the EFT. The graduate students each took on different self-selected production roles such as hosting, directing, running a 'camera'/iPad, floor directing, and facilitating the question and answer segments with the schools. Ashley said:

> What I really enjoyed seeing, personally, was that everyone rotated through all the stations and through all of the work. I know in a class like this it is kind of easy to like get backed into a corner where you are doing one thing - you're just the interviewer, or you're just the camera person. So, it was really great that it seemed like everybody had a similar experience, and they all got to do every aspect of the interview and the process.

While scientists were satisfied with their EFT roles and time commitments, they did discuss their experiences in front of the mobile live webcasting devices were somewhat confusing and different from typical studio camera set-ups. They discussed:

> Steven: I've been in front of the camera quite a few times, but one thing that was really different this time, when we were doing the segments, I would easily forget which camera was focused on me. And so, only when the other cameras were really tight and it was obvious, did I know where to look. There are no little red lights on the cameras [iPads], so that…when anyone is really inexperienced, or even when you've been on a few times you know you are looking for 'okay, where am I supposed to be looking?' I would forget on this one.
>
> Ashley: I know of at least one time, I got elbowed by you because I was looking at the wrong camera.

The scientists, therefore, requested that the production crew give more specific on-camera direction and guidance for similar future mobile programs. The participating graduate students agreed and seconded the need to increase production crew-to-scientist direction and communication during the live webcast.

During each live, 45-minute webcast at 2:00 p.m. and 4:00 p.m., participating middle and high school students viewing the streamed video could submit typed questions for the scientists into a textbox within the streaming website. Students submitted an estimated total of 82 questions combined across both webcasts. Scientists discussed that this was somewhat of a new and challenging way for them to engage with youth since they have more experience delivering outreach programs through in-person formats. Amity stated:

> I like seeing little kids. I can kind of like react more to what they are saying. So, having that disconnect was a little bit weird for me, at first, but I kind of got used to it - as we kind of went on with it, and just trying to remember that I am not talking to a college-aged person but I am talking to a 10-year-old or something like that was something that. I had to keep reminding myself because I couldn't see them in front of me.

Graduate students in the production crew monitored youth's questions and asked scientists many of the questions during the three question breaks within each live webcast. Amity said,

> I love the questions, and I find that I always get questions that I don't know the answer to. I had to look up what the fear of bats is called. I had to Google that because I went 'I don't even know that.'

The scientists echoed that the youth engagement was their favorite part of the experience and how the submitted questions kept them on their toes. Ashley discussed,

> I am always surprised by the level of questions that come in from younger kids. There is always plenty of very interesting and very well-informed questions, so I think the questions are way more interesting and fun to do. I really liked those segments.

Steven said:

> Somebody asked: Do you know what is the breeding season [for bats]? At first, you think, 'Oh no, what is the breeding season?' Then, you think, 'There are thousands of species of bats. Generally speaking, breeding season is when it is warm.' You can make your way through those [questions]. It's [the knowledge] back there somewhere, and you can usually pull it out.

While the scientists noted the technology did not afford the same interpersonal aspects of face-to-face engagement, they quickly adapted to the online format and recognized its benefits to reach larger audiences. All three scientists agreed an EFT is an effective way to increase

youth wildlife and climate science awareness and interest.

Student and scientists recommendations for more scaffolding within the PjBL design, improvement of EFT question segments, and to expand the experience beyond a one-semester course. (RQ 3)

In regards to the design of the PjBL course, several of the graduate students requested more overall structure and guidance. Their recommendations included incorporating more opportunities for practice and a more detailed explanation and preparation before the EFT. They discussed potentially adding in additional assignments, skills tests, and more front-end rehearsal time before going live. Lauren discussed she'd like more time for practice earlier in the semester to feel more comfortable and confident with the technology. She said:

> …even if it is to check out the iPad through the week and play with what technology is on there. As someone who had no background whatsoever in this, I think that is probably my biggest take-away. I think maybe not necessarily week one, but the second week – 'okay, let's get out the iPads and play with this a little bit, and let's see what the imaging system looks like, let's see how it is to move photos from this to this' and that sort of thing."

Sydney recommended that students demonstrate their understanding of how to use the technology in a more systematic way. She discussed:

> I am not a huge advocate of saying more tests, but there could be a test to see if you actually can connect all the technology together. Make that a grade, so that we do for sure know exactly how. I am pretty confident that I know how to do it now, but I might have forgotten a step, and if I was tested on it, I would for sure know.

Jared recommended that the class create a more detailed script for the live webcast. He said:

> I would have liked to have more of an outline of the questions of what the hosts would ask the scientists. Maybe a little bit more in-depth than what we had, so that I could better prepare myself as the director to show - what order to show media in, that kind of stuff. I know we don't ever really know what they are going to say, and that's okay, but just have more of an idea going into it.

Yasmin also requested more specific guidelines from the instructor about production crew members' roles. She indicated a need to better clarify the activities conducted and the skills needed for each role, especially outlining strategies and responsibilities for youth question facilitators.

In regards to the EFT project itself, graduate students and scientists alike suggested improving the production flow of the question and answer segments. Steven, Amity, and Ashley recommended continuing to rehearse with scientists with prepared questions so that they can get in the mindset to be ready to answer youth's questions during the live webcast. Amity said, "There is nothing worse than being like, 'I don't know.' Amity added, "I would continue practicing out ahead of time… that seemed to be very important to the smoothness of the actual day." During the EFTs, the hostess and scientists would stand in one location in front of the bat houses to present the content, then they would walk over to the nearby table where crew members were facilitating student questions. Sydney described the confusing transitions between segments, "I felt just a little awkward like, 'I don't know if I am on camera or if I am not.' I was kind of smiling." The graduate students and scientists all recommended smoothing out the positioning and production elements of the question and answer segments.

All of the graduate students and scientists advised continuing the PjBL EFT class and expanding it to include further opportunities such as collaborative internships with the university's museum, targeted engagement with international schools where the scientists collect data, webcasting live from additional research field sites in a variety of locations, and potentially adding a study abroad component for streaming live from international locations. As an example, Steven described:

> It could be something as simple as a [follow-up] short class that is taught over spring break, where we've got six groups of researchers from the museum all working in The Bahamas at the same time on insects, anthropology, and bats - and you go to three or four of these sites in a week. You get a three or four-hour credit for that very intense class, but you can do that because you are already trained up on it.

Graduate students shared a similar perspective that they would welcome the opportunity to participate in an extension of the course to further develop and apply their EFT production and research skills. Overall, the students and scientists agreed the class and EFT were a success, but there is room for growing the experience beyond the single EFT to ensure richer, more in-depth learning occurs.

Discussion and Implications

Overall, graduate students and scientists described positive experiences in developing and conducting an EFT for middle and high school students. Graduate students delivering the EFT were extrinsically and intrinsically motivated to build their digital literacy skills through their participation in the course studied here. The graduate students were able to develop skills to effectively communicate science (Turney, 1994), better fulfill the land-grant mission (APLU, n.d.; Rasmussen, 1989; Seevers & Graham, 2012), target their appropriate audiences (Bray et al., 2012), and gain knowledge relating to bats, climate change, and wildlife empathy (Turney, 1994). The

graduate students appreciated their opportunity to apply the communication skills learned in the classroom and in the field (Turney, 1994) and even wished for more opportunities to practice their skills. The students expressed their excitement with the ability to gain video and production skills through this course which Johnson et al. (2016) would consider development in creative literacy.

Although serving in a different capacity, the scientists gained knowledge and skills relating to the production of an EFT as well. The scientists were enthralled with the ability to engage students about bats, climate change, and wildlife empathy through an EFT, which has not been their mode of communication and education with previous audiences (NASEM, 2017). The lack of practice communicating science to audiences in this format provided a learning curve when it came to interacting with the streamed audience, as compared to an in-person audience (NASEM, 2017). The scientists were impressed by the level of skill that the graduate students possessed in terms of designing, producing, and delivering an EFT, indicating that the digital literacy skills gained through this course will be beneficial to the students, as they enter their respective professions (Griffin et al., 2012).

Limitations, Recommendations, and Future Research

A limitation of this research is the self-study design. The design allows room for bias to be introduced due to the personal connection to the data. To decrease potential biases, the second author conducted the complete coding and categorizing portion of this study. Collecting data via interviews and a focus group provides limitation to this study as well. The course instructor/lead researcher as the focus group moderator could have potentially caused the focus groups participants to provide biased responses and the moderator facilitating biased discussions. Additionally, for both the focus groups and interviews, not all participants were equally verbal in their responding potentially causing some viewpoints to be expressed more in-depth by some participants.

Future research should continue to be conducted around EFTs because of the evolving nature of technology. EFTs could be conducted with the same tools with a variety of scientists and science topics that are considered complex and controversial such as climate change, growing a secure food supply, and other quality of life advancements (Nisbet & Scheufele, 2009). Research could assess participating students' immediate and long-term knowledge gain, behavior intention due to their participation in the EFT, and overall perceptions related to the chosen topic. There is an opportunity to extend the reach of EFTs beyond the school-aged audience to adult-aged audiences. Research could be conducted to assess adults' participation in EFTs and online learning. EFTs could also be conducted through other platforms (e.g., Skype in the Classroom) to determine if other platforms have more ideal features for online learning, more schools/students are willing to participate, or students are more or less engaged.

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