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Scientist Online: Entomologists' Experiences Engaging With School Audiences Through Skype in the Classroom

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Scientists often aim to inspire others who may not be as knowledgeable about specific scientific concepts to increase science interest and knowledge, mobilize communities for social and political change, and encourage the pursuit of STEM careers. Ideally, scientists would interact with public audiences face-to-face for rich dialogue and engagement at community venues such as libraries, churches, schools, and grocery stores. However, research shows the majority of Americans spend their time searching for scientific information on the web. As an alternative, some scientists have taken to participating in produced online video. Some online video platforms allow for synchronous dialogic engagement, such as Skype, for video-sharing. Skype in the Classroom is offered for school interactions with content experts through virtual field trips. The following study provides a practical overview of a specific program called "Scientist Online: The Science of Mosquitoes," its application of Skype in the Classroom two-way video technology for fostering STEM dialogue, and a qualitative analysis of scientists' experiences and scientist-student interactions. The authors analyzed interviews with the participating scientists and call transcriptions of the scientist-student conversations with five schools and more than 100 students from Florida, Pennsylvania, Canada, and Pakistan. Skype in the Classroom served as an effective platform for scientists to engage with various school audiences, improving their confidence in science communication. The online synchronous format of Skype in the Classroom prompted scientists to prepare content and conduct background research of participants' locations in advance. Scientists recognized the importance of their roles as science communicators to dialogue about science in digestible terms, and Skype in the Classroom allowed them to balance their roles as researchers and contributors to public outreach. Recommendations are also discussed.

Keywords: public outreach and education, science communicaion, science educating, STEM careers, video-sharing, dialogic model, dialogic model of communication, Skype in the Classroom

INTRODUCTION

Americans' confidence in scientists has steadily increased in recent years, yet research shows those who trust science often have an existing high level of science knowledge and politically tend to be Democrats (Funk et al., 2019). A science communication myth exists that the public is uneducated and scientifically illiterate, and that simply supplying information will solve the science knowledge gap (Nisbet and Scheufele, 2009). However, research has shown this Deficit Model way of thinking and communicating is ineffective and simply providing information does not promote literacy or knowledge gain [National Academies of Sciences, Engineering, and Medicine (NASEM), 2017]. It is imperative that scientists and science communicators instead participate in targeted and sophisticated two-way public engagement for promoting education and change (Nisbet and Scheufele, 2009). Learning theories and research indicate a learner is more likely to commit new information to memory through active learning and engagement (Kolb, 1984; Markant et al., 2016).

Scientists are often motivated to share their awe and love of science with public audiences to potentially inspire others who may not be as knowledgeable about specific scientific concepts to ultimately increase public science interest and knowledge to mobilize for social and political change in communities, as well as the potential pursuit of STEM (science, technology, engineering, and math) careers (Nisbet, 2018). Ideally, scientists would interact with public audiences face-to-face, in-person for deep, rich dialogue, and engagement at community venues such as libraries, churches, schools, grocery stores, and restaurants (Nisbet, 2018). While in-person engagement is ideal, research shows the majority of Americans spend their time searching for scientific information on the web (Brossard and Scheufele, 2013).

The current Information Age, need for distance education and engagement of a mobile smartphone society, and dwindling travel budgets have decreased opportunities for scientists to engage directly in-person with public audiences (Lacina, 2004; Lukes, 2014). As an alternative, some scientists have taken to participating in professionally produced online videos and even developing their own multimedia for reaching public audiences (León and Bourk, 2018). For instance, Sugimoto et al. (2013) found scientific scholars have participated in TED (Technology, Entertainment, Design) talks for in-person audiences, which are then shared more widely for online viewership. The researchers examined 1,202 TED talk videos on YouTube with 998 unique presenters from 11 universities around the world, and they found the videos had hundreds of thousands of views and increased participating scientists' online visibility which could potentially increase public popularization of science. Welbourne and Grant (2016) examined science communication videos on YouTube ($n = 411$) and found user-generated videos were just as popular as videos created by science communication professionals. The researchers stressed that video producers (users or professionals) should consider YouTube as a platform for two-way engagement with audiences via comment interactions and ratings, so as not to simply post content and ignore interaction opportunities.

Video engagement for increasing science literacy occurs in several different formats across formal, non-formal, and informal settings, and technologies. Teachers often use video in PK-12 classroom settings to introduce students to scientists, STEM careers, science concepts, and laboratory and field locations not accessible via physical class field trips. Higgins and Moeed (2017) found that students valued viewing 10–20 min pre-recorded science video clips along with integrated reflective and discussion activities for deeper learning. In addition to pre-recorded video clips, teachers can implement live television and web-casted electronic field trips (EFTs) for increasing STEM engagement and learning (Adedokun et al., 2011, 2012a,b). EFTs typically include a subject matter expert in a field or laboratory location connecting with youth synchronously through live video and interactive chat about a focused topic or theme that enhances STEM classroom instruction (Loizzo et al., 2019).

Some online video platforms allow for synchronous EFT dialogic engagement, such as Skype for video-conference calls (Morgan, 2013; Skype, 2020). Through Skype, multiple sites can visually see and hear one another via online video and audio connections. Additionally, Microsoft offers Skype in the Classroom for specific PK-12 classroom interactions with content experts and virtual field trips (Foote, 2008; Skype in the Classroom, 2020). Teachers have leveraged Skype for a variety of engagement events such as to connect international students with English speaking virtual guests to practice conversing with one another (Tsukamoto et al., 2009). Classrooms can also connect with scientists to meet them, see where they work, and ask questions about topics they learn in their school's science curriculum (McCrea, 2012).

Research has shown scientists are typically depicted as stereotypical white male scientists in lab coats mixing chemicals and that female youth often lose interest in STEM disciplines, sometimes due to perceptions of scientists as mostly male working in labs all day (Lane et al., 2012; Ferguson and Lezotte, 2020). Social cognitive theory posits that imagery through media and vicarious engagement with role models could enhance motivation and learning (Bandura, 2001). Technologies such as Skype in the Classroom can provide interactive video dialogue to promote richer engagement and learning, as well as introduce students to a variety of scientist role models, science settings, and foster relationships that might not have otherwise been possible (Adedokun et al., 2012b). Research has shown EFTs can positively impact youths' STEM perceptions of scientists and careers (Adedokun et al., 2012a). The following section continues to build upon science communication and video research to introduce the conceptual framework that guided this study.

CONCEPTUAL FRAMEWORK

According to the National Academies of Sciences, Engineering, and Medicine (NASEM) (2017), science communication is defined as "an exchange of information and viewpoints about science to achieve a goal or objective such as fostering greater understanding of science and scientific methods or gaining greater insight into diverse public views and concerns about the science related to a contentious issue" (p. 2). Communicating the sciences requires various skills for evolving scientific topics and diverse audiences, yet there is a lack of training for teaching scientists [National Academies of Sciences, Engineering, and Medicine (NASEM), 2017]. To improve communication, emerging scientists should take classes or training in communication (Nisbet and Scheufele, 2009). The extent of training is problematic, since science communication programming ranges in its foci, goals, and duration—many varying from one-day training, semester-long courses, to higher education degrees from universities (Baram-Tsabari and Lewenstein, 2017). Additionally, some emerging scientists report the lack of opportunity to practice communication (Cerrato et al., 2018). Furthermore, scholars dispute which communication model to teach and practice (see Trench, 2008).

In the past, science communication operated in a deficit model, where the experts in a scientific field would transfer information through one-way communication channels to individuals who were perceived to lack the knowledge or had a deficit content knowledge (Trench, 2008). Since World War II until the 1980s, this theoretical model influenced the approach to communicating sciences to the public (Schiele, 2008). Science communicators tried to replace the deficit model with the "contextual model," where science interests are based on one's contexts and curiosities (Cheng et al., 2008, p. 2). Nevertheless, both the deficit model and contextual model lend to science communication between two distinct parties, science and society, with one leading over the other (Cheng et al., 2008). Many scientists see the "other" or the "public" as a homogenous, non-scientific group, which discounts the nuances of the audience (Simis et al., 2016). While some scholars argue the deficit model is "wrong" [National Academies of Sciences, Engineering, and Medicine (NASEM), 2017, p. 3], other scholars, such as Trench (2008), believe the commonly held models of science communication (i.e., deficit, dialogue, and participation) work best in particular contexts. However it is argued, the deficit model persists due to scientists who have less affinity toward the social sciences, ultimately perpetuating the top-down approach to science communication (Simis et al., 2016). Thus, scientists need training in the social sciences and practice in communication to communicate salient topics in the sciences with audiences effectively.

Scholars argue public science engagement should not occur through persuasion or marketing because those methods would only reinforce the deficit model's top-down approach, ultimately compromising the public's trust (Nisbet and Scheufele, 2009). The dialogue model encourages two-way communication where audiences use their information and experience to contribute to the communication process (Trench, 2008). Two-way communication is commonly seen in communication theory within the field of public relations, which has permeated into the science field (Kent and Taylor, 2002; Trench, 2008). Other two-way model names include "science in society," which does not support that knowledge is transferred from two unequitable groups, but between multiple groups with equal relationships (Casini and Neresini, 2012, p. 37).

Dialogue has multiple definitions, but it is essential to distinguish that dialogue is not a process but rather, a product of reiterative relationships and communication within those relationships (Kent and Taylor, 2002). The relationships are evolving with global connectivity through innovative technology. With the emergence of online media, stakeholders have a greater voice in organizations and decision-making when utilizing the dialogue model (Pang et al., 2018). Other research indicates age and communication experience impact the relationships scientists have with different audiences within the dialogue model. Cerrato et al. (2018) contended young and emerging scientists (23–29 years old) engaged in a dialogic approach to communication because they wanted to share their passion and felt socially responsible. Moreover, Cerrato et al. (2018) found that among Spanish scientists studied, younger scientists had more formal training with science communication than their older colleagues. Interestingly, science communicators recognize the importance of the dialogic model, yet it is rarely emphasized in training (Yuan et al., 2017).

The following study applied dialogic science communication thinking to a two-way video EFT engagement program between scientists working in a real-world laboratory setting and youth participating from their classrooms. Using video as a medium to connect scientists to classrooms is not a new phenomenon (Falloon, 2012). The use of video to connect scientists with students, in conjunction with other mediums of information, may encourage middle school students to pursue various careers in STEM (Wyss and Watson, 2013). Creating a dialogue between students and scientists via video conferencing can give teachers flexibility in their classrooms and help students see a broader scope of careers in the sciences (Chen and Cowie, 2014). Videoconferencing can be a resource to connect students and scientists, yet it can be expensive and consume resources (i.e., time and money) when trying to coordinate lessons with the changing curriculum (Falloon, 2012). Many teachers already use Skype at their schools, so little additional technology resources are needed to use Skype in the Classroom (Maughan, 2020). For instance, Skype in the Classroom requires only a free Skype account and Microsoft account, an internet connection, a webcam, microphone, and speaker (Maughan, 2020).

PURPOSE AND RESEARCH QUESTIONS

The purpose of this study was to explore participating scientists' perceptions of science communication, as well as their experiences participating in synchronous, live video web-streamed, interactive EFTs and communicating their science to diverse PK-12 audiences. The research questions guiding this study were:

RQ 1: What are scientists' views of public engagement and outreach?

RQ 2: How do scientists' view their roles in public science communication?

RQ 3: What are scientists' overall experiences teaching entomology content via Skype in the Classroom platform?

RQ 4: How do scientists navigate interactive dialogue with a variety of PK-12 audiences via the Skype in the Classroom platform?

METHODS

The EFT programs were conducted in partnership with Streaming Science (2020), and online student-led science communication platform, and the Public Issues Education (PIE) Center at the University of Florida. The Florida Department of Health funded the project, as part of a public mosquito education and research grant. The specific project examined was titled Scientist Online: The Science of Mosquitoes, and the facilitation and scientist team used Skype in the Classroom as the registration and delivery channel for connecting scientists with schools in real-time via web-streamed video and audio.

The authors served as program facilitators and researchers and conducted a qualitative descriptive case study (Yin, 2018) including interviews with three university entomologists who participated in the EFTs, as well as analyses of Skype call transcriptions. Scientists connected with five schools with more than 100 students from Florida (one elementary classroom), Pennsylvania (two classrooms viewed from two different elementary schools), Canada (two middle classrooms viewed from one school), and Pakistan (all male boarding school with one classroom of adult learners).

Scientist Online

The Science of Mosquitoes took place in April 2019 and included Skype calls covering content focused on mosquitoes, mosquito-borne illnesses, prevention and protection, and entomology careers. The three university entomologists were selected to participate in the Scientist Online program, based on their involvement with the FDOH mosquito grant (see **Table 1**).

Prior to hosting Scientist Online, we created a promotional web page via the Streaming Science WordPress page, as well as a web page through Skype in the Classroom to serve as the program's recruitment and promotion platform. We scheduled a meeting with a Skype professional, in order to clarify how the Skype in the Classroom platform works and how we could customize their web template to meet our program's needs. Through Skype in the Classroom, we were able to provide a Scientist Online program description, introduce the scientists, and allow teachers to register their classrooms on available production days on a first come, first serve basis.

After creating the Scientist Online site through Skype in the Classroom, we met with the entomologists to discuss program logistics. We explained the equipment set-up, encouraged them to create a content script or outline that would meet the program's learning objectives, and supported their ideas to use visual aids/props. Following the initial meeting, we met one of the entomologists in the lab a few weeks prior to our first production day to practice setting up the equipment and rehearse the Skype call.

On the production days (see **Figure 1**), equipment included: (a) a laptop on a cart with a head and shoulders, medium framed shot of the scientist during the call, (b) an iPad used for close ups of the props and to follow the scientist around the lab, (c) a microphone clipped to the scientist, and (d) headphones attached to the iPad in order to avoid audio feedback between devices. It is important to note that our team used two separate Skype accounts in order to have both devices logged in simultaneously during the calls. Scientists used props including

FIGURE 1 | Behind the scenes of Scientist Online. An entomologist shows a mosquito cage to students participating via Skype.

TABLE 1 | Scientist pseudonyms, degrees, positions, and locations of Skype schools connected with during their EFTs.

Pseudonym	Degrees	Position	School locations
Amy	Ph.D. Entomology B.A. Biology	Assistant Professor	Canada Pennsylvania-Classroom 1
Carol	Ph.D. (Candidate) Entomology and Nematology M.S. (Candidate) Public Health B.S. Entomology and Nematology	Lab Assistant Student	Pennsylvania-Pennsylvania Classroom 2
Rose	M.S. (Candidate) Entomology and Nematology B.S. Biology	Lab Assistant Student	Florida Pakistan

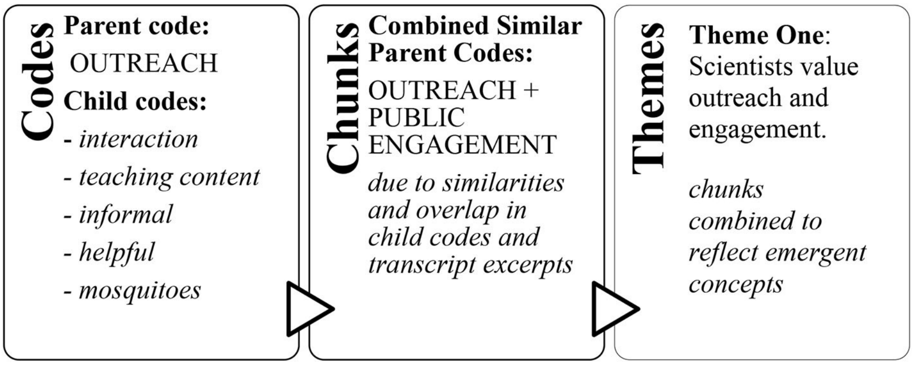

FIGURE 2 | The researchers' qualitative coding process for arriving at thematic results.

(a) plastic figurines to illustrate the life cycle stages, (b) plush mosquito, (c) PowerPoint slides of mosquito photographs, and (d) a screened-box of live mosquitoes.

Once all of the Scientist Online EFTs were completed, the first author recruited the scientists to participate in approximately 30-min, semi-structured interviews via Zoom, a video conferencing platform that can video and audio record and transcribe the conversation. Examples of interview questions include: (a) How would you describe your Skype in the classroom experience for the mosquito project? (b) What Skype in the classroom moment stood out to you the most? (c) What were some of the students' questions that stuck out to you and how did you handle those questions? (d) How did you plan to prepare yourself for call? We downloaded the Zoom interview transcripts into Microsoft Word to clean and verify them. Then, we uploaded the transcripts into Dedoose, a web-based software application that allowed us to organize and analyze the data.

The lead and second researcher open and axial coded interview transcripts and Skype EFT dialogue transcripts for emergent themes (Saldaña, 2016). We used the constant comparative method to develop deductive and inductive transcript codes, grouped codes into chunks, and ultimately combined chunks into themes (Glaser, 1965). The third researcher reviewed codes and verified interpretations throughout the coding process. **Figure 2** provides an example of the coding process.

To achieve validity in the study, researchers triangulated the data which included: (a) three interviews with the participating scientists, (b) five transcripts of the Skype calls, (c) researchers' field observations and (d) interviewed scientists were asked to review quotes and interpretations. The University of Florida's Institutional Review Board (IRB) approved the research protocols.

RESULTS

Four themes emerged from the data analysis. The following subsections highlight the themes with samples of supporting data.

Theme One: Scientists Value Outreach and Engagement (RQ1)

Scientists valued public outreach opportunities to develop confidence in their communication skills through a variety of programs. When asked why science engagement is important, Carol replied that scientists should not "do research just for the sake of research." She also explained that:

> I don't think science communication has to be any one specific way because different scientists have different strengths. Not everybody wants to get up in front of a group of 50 people and talk about the science that they do. But that doesn't mean that a scientist can't do something really simple like post a blog or get on Reddit and do an Ask Me Anything session. There are so many different outlets for doing science communication that it doesn't have to look the same for every person. I think that scientists that are scared to do more science communication should just seek out different ways that they're comfortable with doing it and then, just take advantage of those. You don't have to do what your friend is doing. You can do what fits your personality and what fits your comfort level.

Likewise, Rose shared that, "The thing is, everyone's not a good speaker or is engaging, and so I think that, there's sort of a continuum."

As an assistant professor, Amy had her own lab and shared that, "Part of my mission in my lab is education and outreach, specifically around insects and with a focus on ants. We have several, I wouldn't call them presentations, but we sort of have kits ready for going to events."

Each of the scientists were asked what advice they would give to scientists looking for ways to engage with the public. Rose and Carol described local opportunities for scientists to dialogue with people who are curious about science. Rose shared, "The museum on campus [is] developing outreach opportunities, and they want to recruit scientists." Carol explained that when local events are happening, "Make sure that you're present for those, because there's tons of opportunities to engage with the public anywhere you are. It's just that you have to actively seek them out." Amy encouraged, "This [Scientist Online] is probably like a starter, you know, a neat way to try something. Maybe for interacting with people farther away."

In this particular context, Carol admired the Scientist Online program and synchronous video connection, "...makes something like the University of Florida research lab accessible to anyone in the world. So, someone from Saudi Arabia or Vietnam or Pittsburgh, Pennsylvania can call in and get to see a lab that they may not have otherwise had the opportunity to see. So, that aspect of it is really cool." Similarly, Amy thought "there are real advantages [to interactive video], especially for schools that are very far away."

When her first EFT began, Amy enthusiastically greeted the students in Canada, "Thanks for signing up, and [I'm] really happy that you reached out!" As the call was coming to a close, Amy made a point to thank the teacher and students, "...for tuning in and for all of your great questions. I really enjoyed talking to you today. Stay warm and I hope you guys all do well and get interested in the science of insects and the [research] efforts."

One of Amy's most memorable moments during her time with Scientist Online was when:

> One of the teachers said, as the kids were filing out of the room, some kid turned and said something like, "Well now I know what I want to be when I grow up - I want to be an entomologist." So that one awesome comment, that stuck with me, like, "Okay, I guess it works!"

Amy discussed how she was struck by a moment that a student told their teacher they wanted to be an entomologist. She noted how her presentation and video engagement during Skype in the Classroom as a scientist can inspire student viewers to pursue future careers in STEM.

Theme Two: Science Communication Should Be Simple and Engaging (RQ2)

Scientists viewed their role in science communication as relaying new information to the everyday person in consumable ways to promote change.

Carol explained that she believed, "Every scientist should make an effort to make the research that they do digestible." She said scientists should make it a goal of theirs to participate in outreach initiatives regularly. She continued by explaining that if people are able to learn about the vastness of research and what "goes on behind the scenes" people will be more on board when "something like a new insecticide is released or a new thing is discovered about a virus." Similarly, Amy said, "it [science communication] has to do with people who are not involved in generating science and so public audiences, communities, stakeholders, and so on. Not just advancing the field."

After interacting with the students during Scientist Online, Carol described her presentation process for teaching mosquito appreciation and mosquito-borne illness prevention to younger audiences:

> I wanted to just explain what the life of the mosquito looks like from start to finish. Because if you understand that, you can understand what you can do to prevent them [mosquito-borne illnesses]. So, a lot of people do not know that mosquitoes spend part of their life in the water. And if you know that they spent part of their life in the water, then you know that by getting rid of water or treating water that you can prevent their development. So, I tried to focus a lot on the life cycle, but also that mosquitoes are not just all these terrible creatures that are always hurting us and always biting us. There is such a crazy diversity of mosquitoes and they can actually be really beautiful. So, I tried to show pictures of mosquitoes that were not ugly and that don't feed on people, so that they could see just how awesome diversity is out there in the first place.

Amy also wanted to teach about the diversity among mosquitoes and science as a whole. She said she "...was really happy to have some conversation about how we do the science, who was doing the science. So that was nice." When reflecting on a challenging question and teaching moment, Amy recalled:

> People did have some really interesting questions about mosquito control, and because that is a really tough topic to answer questions about, basically the answer was, "That's a really good question, and I don't have a specific answer for you. But here are some of the challenges that I'm trying to figure out." The kind of questions like to spray or not.

When Rose "...wanted to talk about mosquito diversity and how not all mosquitoes bite people and different mosquitoes carry different vectors for different diseases," she used props as visual aids and thought that "...the photos [were] really great for that because [the mosquitoes] all look so different."

All scientists expressed their efforts toward creating an engaging and informative experience for the students. They intentionally framed concepts in digestible ways depending on the audience's interests regarding mosquito control and prevention.

Theme Three: Plan Ahead, Prepare Content, and Use Visual Props (RQ3)

Scientists found teaching specific scientific content and learning objectives via an online interactive video platform required planning and preparation, as well as a variety of visuals for piquing viewers' interests.

Hosting the Scientist Online program was different from the usual outreach and engagement opportunities that the scientists had done before. When recollecting their past outreach experiences, the one thing Carol "...had really ever done that was similar is I've given talks online, but that I don't feel like it's the same because it's not interactive." Rose thought that "...in person, you might have a little more one-on-one interaction with different people, instead of the group as a whole. I do feel it's a little more formal just because I can see myself and like when you guys were there, [with] two cameras on me." When asked what was different about planning for the EFTs vs. an in-person interaction, Carol felt:

> Things go a lot faster when you're in an online environment. So, you have to have more material prepared than you would in a live

> [in-person] environment because in a live environment, people feel free to just raise their hand immediately when they have a question, and so, I felt like I was flying through material that would have usually taken me double the amount of time to talk about with a live group. That was definitely different, meeting to prepare a lot more information.

In order to adequately prepare, the facilitators encouraged scientists to plan ahead in whatever way worked best for them. All of the scientists chose to create a learning objectives outline and script to guide their calls. Rose said she "...really love[d] that we made our script. Once we decided on what we were actually talking about, and it wasn't even really a script. Just kind of points to cover." Amy described her planning and preparation technique as:

> I had a printed-out guide of what is basically like my backup plan. If no one asks any questions, this is what I'm going to talk about. And then, I tried to adjust what I was talking about, to what the questions being asked were. So, if a student did come up and have something to say while I was talking, I would just kind of try to follow that track and then eventually I would circle back to the written plan that I had for myself and then just cover those topics.

During the planning and preparation process, the scientists decided it would be helpful to have visuals and props similar to how they would during an in-person, face-to-face outreach event. Scientists used a variety of visuals to engage the students, including PowerPoint presentations with photos, visual props, and a box of live mosquitoes in the lab. Amy recalled "...how excited people were about these little plastic [mosquito] toys that we showed." Carol showed students around her lab and the place where they keep live mosquitoes, "I also brought some live mosquitoes for you guys to look at, as well. Here are some mosquitos in here" [Skype transcript- Pennsylvania: Classroom 2]. Carol also used a visual prop to review the body parts of a mosquito with her students. Additionally, all three scientists showed photographs to explain content such as mosquito body parts and the variety of the different species. Supporting examples from program transcripts include:

> "If you look at this picture here, what you'll see is that from the head, those mouthparts have now separated out." [Skype transcript-Canada]

> "I'm going to show you a series of photos of mosquitoes, just so you can get a sense of some of the diversity that's out there." [Skype transcript-Pennsylvania: Classroom 1]

> "We have a PowerPoint with some photos we can show you, too, some really cool close-up photos." [Skype transcript-Pennsylvania: Classroom 2]

All of the scientists expressed some room for improvement when considering the Skype platform. While several schools registered via the Skype in the Classroom website, some did not show up for their reserved time due to time zone issues, health reasons, or technology limitations. Carol said it is important to "...make sure that schools are going to tune in at all, so that you don't have people preparing for the outreach activity, and then, no one showing up." Amy shared a related observation about her Scientist Online experience:

> It was good except that I think that the connectivity issues or the commitment issues from whether or not the school showed up at all became the issue. So, that was hard and maybe a little bit sad for the students involved. So, if there was some way to get commitment from the classrooms, or a little bit of information from them ahead of time about what they were interested in, or what their background knowledge was, that would be really helpful because I think that's all about knowing your audience and tailoring the content for those students.

Another ubiquitous point shared by all of the scientists was that the entire program arrangement was made more enjoyable because the team of communication professionals was there to facilitate, coordinate, and assist with the preparation, planning, and production details. Rose shared, "You guys made it very easy. I thought it was great that I could sort of devise what we're going to talk about, set up my props, but like the logistics, you know, were sort of handled by you all." Amy expressed that:

> I think probably the best part of it was that you guys do all the work ahead of time. I mean, I didn't do any arranging with classes, you all basically did it. Because getting the technology setup I think was a big part of it, and that's often the burden. Also, there's a time burden of coordinating with people but with you all, it was easy.

Like the other two scientists, Rose was impressed with the equipment used during the calls, "I think you guys have really nice equipment, so it didn't look like garbage. I think that part of it felt very professional, and that was cool."

When hosting a Skype in the Classroom call, scientists should consider planning ahead, preparing content, and utilizing props. Presenting to in an online environment left the scientists to prepare engaging and relevant content. The scientists used various strategies to capture the students' attention while also recognizing the support they received from a team of communication professionals regarding production.

Theme Four: Adjust Content and Dialogue for Diverse Audiences (RQ4)

The Skype in the Classroom format challenged scientists to adjust to participating learners' backgrounds, ages, knowledge-levels, and country of origin. The classes of students were a wide range in ages and levels in school. For the Pakistani classroom, the scientists asked higher level questions because the class was from an all-male boarding school and more advanced in their education. For instance, Rose asked, "How do people become infected with Plasmodium?" A student responded,

> The male mosquito inject[s] the Plasmodium into humans, so when the female mosquito come[s] to suck the blood, they suck the Plasmodium, and they do produce eggs inside the

stomach and the malaria parasite which cause[es] malaria as well. [Skype transcript-Pakistan]

With younger students, the questions posed by scientists to students were simpler, "What is your favorite thing about mosquitoes?" and "Does anybody in your group raise insects as pets?" [Skype transcript-Pennsylvania: Classroom 1]. Additionally, with the younger students, scientists used warm and enthusiastic language toward science and science topics, such as "cool" and "love." Examples included the following:

"I love to talk about this topic [scientific discoveries," [Skype transcript-Canada]
"I just think they [mosquitos] are really cool to be around" [Skype transcript-Pennsylvania: Classroom 1]

To engage students, scientists did not treat the Skype classrooms like a distant space. Instead, they fostered the synchronous learning environment by asking the students questions, having the students raise their hands, and selecting students as if they were physically in their environment.

Here's my quiz for you. First, I want to know, how well do you know mosquitoes? One of these three insects is a mosquito, so raise your hand if you think "A" is a mosquito. Raise your hand if you think "B" is a mosquito. Raise your hand if you think "C" is a mosquito. Wow, you guys are right. "C" is in fact, a mosquito. Does anybody want to offer a reason that helped them know that "C" was a mosquito? Is there something about its body that you see that tells you it's a mosquito? [Skype transcript-Pennsylvania: Classroom 1]

The scientists also adjusted their dialogue depending on the classroom's country of origin. For instance, scientists prepared by learning aspects of the audiences' location, including their differing ecological environments and prevention practices. Rose discussed marshy environments with the Pakistani classroom and then, she asked students what they did to prevent mosquitoes, the students discussed the insect repellent Mospel and mosquito nets. In the Pakistani classroom, Rose elaborated on additional mosquito protection and prevention with the use of mosquito nets, staying indoors, and swatting them away:

You guys use the mosquito nets and long sleeve shirts...and not going outside when they're really active outside or staying away from areas that are marshy...Are you guys good at swatting them too or in like the air? [Skype transcript-Pakistan]

In comparison, Amy discussed lakes and rivers with the Canadian students and prevention measures like screens on windows, dumping sources of water around homes, and staying indoors:

Some things we can do, also, you can't get rid of lakes and rivers, but you could dump containers if they have water around your home because that's a big source of mosquitoes that are very close to people, so flower pots and things like that. [Skype transcript-Canada]

For the classrooms in Pennsylvania, the scientists discussed several ways to prevent mosquitoes including repellent, the use of screens, and keeping indoor space cool with air-conditioning. Additionally, with sixth graders, Carol emphasized what they could do with their toys around their home:

I'm sure you guys have toys around your house, right? Do you guys ever play outside and leave your toys outside or something? Water can collect in those different types of toys, so what you have to do is go around your house and look for any place where water is collecting. If there's a tarp in your yard or a bucket, or maybe a slide or something like that, where the water is just pooling, you want to make sure that you dump out that water so the mosquitoes can't develop in it. Does that make sense?

Scientists were informed of the grade level and geographic region that the schools they were hosting a call with. Through interviews, scientists expressed their strategies to adjust their approach and jargon associated with mosquito control.

CONCLUSIONS AND RECOMMENDATIONS

It is essential to explore the impact of digital, video-based science communication methods on scientists' approaches, and experiences communicating with various school audiences. Especially considering the Covid-19 pandemic and its impact on the education system. "Scientist Online: The Science of Mosquitoes," its application of Skype in the Classroom two-way video-sharing technology fostered a virtual student-scientist interaction. The Skype in the Classroom format challenged scientists to create compelling content for students of various ages and backgrounds. Examining programs like Scientist Online can inform educators and science communicators on how to best approach teaching remotely.

The results of this study suggest that scientists value outreach and engagement opportunities. Each entomologist expressed the importance of every scientist exploring their preferred method of science communication whether that be at local community events, classroom presentations, social media outlets, invited talks, or even virtual interactive video programs like Scientist Online. All of the scientists understood that science communication efforts should strive to be simple and engaging.

This program challenged the scientists to intentionally adjust their content depending on their audience's age group and country of origin. For example, classrooms from Florida, Pennsylvania, Canada, and Pakistan participated in Scientist Online. In order to feel prepared for the program, each scientist spent time creating an outline or a script with information connected to the program's learning objectives about mosquitoes and their life cycle, mosquito-borne illness, and prevention and protection. However, each scientist shared that they did not strictly follow their outline during the program. This afforded the students with the opportunity to engage in a real conversation with the scientists. Therefore, each scientist had various conversations with the different classes. Some of the conversations ranged from specific inquiries about mosquitoes and vector diseases, to mosquito prevention measures, and even questions about weather conditions in Florida compared to theirs out of the state.

The researchers recognize that some limitations were present in this study. The study included three female entomologists, two of them worked together in the same lab, to richly examine their experiences with interactive, real-time video webcast outreach programming. Therefore, the results are not generalizable to all scientists and online outreach. However, the results are still of interest for planning similar programs and may serve as a basis for future research relating to digital communication strategies in education and the relationship between scientists and science communicators.

Recommendations include: (a) scientists should first grow their public engagement skills through in-person interactions, before facing the challenges of live video-mediated dialogue, (b) scientists and professional science communicators should work together to maximize potential outreach—the communicators can recruit and register schools, assist in planning content and learning objectives, and provide technical video support, while the scientists focus on audience engagement, and (c) Skype should be used for reaching diverse audiences who typically do not have access to STEM researchers.

As research continues to support the utilization of dialogic two-way communication strategies, scientists and science communication professionals should continue to develop and study programs like these. Future research should explore the impact of live video-based programs on scientists' confidence and communication skills. Additionally, Falloon (2012) found many students were not comfortable talking to experts during video–conferencing sessions due to a lack of trust and need to create a safe space to learn and ask questions with expert scientists. Therefore, future outreach programs like Scientist Online should continue to encourage dialogic student engagement with scientists, in order to foster trust, curiosity, and learning. Ultimately, this study serves as an enlightening example in which video technology and science communication can be combined to create a unique two-way, dialogic learning experience for both students and scientists alike.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Florida Institutional Review Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

CK, JL, and RT: concept and data collection. CK and JL: research. CK, JL, and WS: draft content and writing. CK, JL, WS, and RT: editing. All authors contributed to manuscript revision, read, and approved the submitted version.

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