US-China Education Review A, January-February 2021, Vol. 11, No. 1, 1-15
doi: 10.17265/2161-623X/2021.01.001

Engaging Public in Science Through Scientific Online Storytelling: Proposed Model

Dana Sachyani, Adiv Gal
Kibbutzim College of Education Technology and the Arts, Tel Aviv, Israel

The study aims to examine the public's motives to participate in online lectures via Zoom on scientific topics during the COVID-19 quarantine. A diverse audience (age, education, gender, and scientific background) of 80 participants (on average) joined the online lectures. We applied mixed methods to answer the following questions: What are the motives of non-scientific participants to take part in online scientific lectures through storytelling? Moreover, we examined the implications of the stories on the participants. Using inductive findings, we constructed a model based on storytelling methodology that engages the audience in science. The teaching model we propose addresses science discipline, but can be used for other fields of knowledge, with relevant adjustments.

Keywords: online model teaching, storytelling, science communication

Introduction

Science helps us identify problems, understand their scope, and find solutions. Science helps us understand future directions for our society. Scientists experience scenes of change and discovery that most people will never experience. However, these findings often remain in a very limited community that is familiar with the scientific press in which all the researchers' findings are published (Green, Grorud-colvert, & Mannix, 2018). Since the beginning of their training, scientists practice the use of scientific methodology. This approach typically focuses on testing concise hypotheses by developing and performing methods, analyzing data, and presenting results in a way that builds on existing knowledge and ideally spurs discussions among the closed community of scientists (Sharon & Baram-Tsabari, 2013). It is not surprising that the detached and technical way scientists describe their research contributes to the perception of scientists as professional, objective, and formal (ElShafie, 2018; Pollock & Bono, 2013). The scientific process and norms that guide it contributes to a distant, impersonal yet accurate way of writing about scientific discoveries, which are usually presented in scientific papers and subjected to peer-review processes. As with any form of communication, the language of science is helpful for conversing with people who speak the same dialect: other scientists (Green et al., 2018). In quite a few cases, despite the large investment in writing, scientific publications are read only by the scientific community and do not spread beyond specific disciplines. As Pollock and Bono (2013) wrote, "Under a desert of barren prose, revealed only to those willing to endure the tedious archeological dig necessary to excavate them" (p. 629).

Dana Sachyani, Dr., lecturer, The Center of Education for Environmental Sustainability, Kibbutzim College of Education Technology and the Arts.
Adiv Gal, Dr., lecturer, The Center of Education for Environmental Sustainability, Kibbutzim College of Education Technology and the Arts.

Although scientific methods provide information, scientists must find other forms of communication to fulfill the social contract with the public (Green et al., 2018). Scientists need to bridge science to the public who have no scientific background (ElShafie, 2018; Martinez-Conde & Macknik, 2017). Following this insight, a growing number of scientists argue that sharing discoveries within the scientific community is not enough. As science helps us understand future directions in our society and identifies potential problems and solutions, scientific discoveries have a greatest impact when they are widely shared with those who can implement solutions and lead change. Thus, the public funding that most scientists receive (i.e., a "social contract") should address urgent social needs through research and deliver findings widely with "good judgment, wisdom, and humility" (Green et al., 2018).

Literature Review

Our framework is based on the two lenses: science communication and storytelling.

Science Communication

The media is the main source of information for the general public for science and technology news (Rodder, 2011). It has a decisive influence on the shaping of the image of science, and scientists in society, public opinion, and knowledge, decision-making at the personal and national level (Fischhoff, 2019; Lutz et al., 2018). The field of science communication addresses how the public perceives issues of science and society, and how mutual understanding between scientists and the public can be enhanced (Baram-Tsabari & Osborne, 2015; Valinciute, 2020).

Why is it important to engage the public in scientific issues? This is a crucial question that interest scientists, educators, and media personnel. There are several reasons for this (Weingart & Joubert, 2019): (a) to make science accessible to the public and enable the public to make science-based decisions about their lives; (b) to democratically influence how its funds are used to ensure political support for bodies engaged in science and research; and (c) to encourage the public's involvement in the research processes and science technology. Common ways to engage a non-scientific public in scientific topics are lectures, press publications, and exhibitions.

Despite efforts engaging non-science public in science, this task may be challenging. One of the challenges lays in the difference between what scientists think is important for the public to know about science and what the public wants us to know about science (Llorente, Revuelta, Carrió, & Porta, 2019). Another could be that scientists think that the public has knowledge lacunae. Scientists think that they must fill these gaps in order for the public to understand their current research (National Academies of Sciences Engineering, 2016). Another challenge in mediating science to the public is known as "paradox of knowledge." According to it, the more one knows about a particular subject, the more difficult it is for him to mediate that knowledge to others (Goldberg & Hanlon, 2019). Today, scientists appreciate the importance of the task of mediation. Therefore, scientists who want to engage the public in scientific topics and their research may join training programs focusing on the matter (Baram-Tsabari & Lewenstein, 2017; David, Garty, & Baram-Tsabari, 2020).

Storytelling

Storytelling is one way to create a bridge between science and the non-science public (Martinez-Conde & Macknik, 2017). Even the most complex concepts in science can be conveyed to the public through storytelling (ElShafie, 2018). Stories provide unique ways to communicate how science intersects with the human experience.

Stories help people understand complex concepts and make science more relevant to their lives (Riedlinger et al., 2019). One of the purposes of storytelling is to promote the scientific education of the public (Zabel & Gropengießer, 2015). Contrary to the perception that science is alienating (Pollock & Bono, 2013), storytelling combines emotions that are critical to connecting the public to science (ElShafie, 2018).

Storytelling has been used to convey wisdom, cultural knowledge, and strengthen social ties since the earliest periods of human existence (Cormick, 2019). Ancient societies told stories by firelight as a human social-cultural event and as a way to pass information and bring meaning to their shared experiences (Joubert, Davis, & Metcalfe, 2019). Accordingly, storytelling can be a powerful tool to engage the public in science (Cormick, 2019) especially if science plays a role in social contexts and makes it more relevant (Riedlinger et al., 2019). Stories help people understand, process, and remember science-related information. Stories may assist in changing people's behavior and interest people in a specific topic (Cormick, 2019; Joubert et al., 2019). Aside being an effective knowledge-sharing strategy (ElShafie, 2018), it may also increase learning motivation (Miller & Pennycuff, 2008), raise awareness, and inspire (Riedlinger et al., 2019). Storytelling reduces objections, is more memorable than just presenting data, increases involvement when passing information to non-expert audiences (Cormick, 2019) and may engage people in environmental activities (Riedlinger et al., 2019). Moreover, stories might be a powerful tool in persuading people to change their attitudes and/or behavior (Dahlstrom & Scheufele, 2018). There are also extensive neurological and physiological effects of listening to a story, e.g., storytelling causes hormone secretion, which promotes concentration and attention (ElShafie, 2018).

On the other hand, some argue that storytelling is problematic as it might avert the data intentionally in order to elicit a deliberate response. Storytelling encourages the unrealistic notion that scientific projects fit into a single story while in reality most experiments have multiple interpretations with many factors and facts (Katz, 2013). There are four reasons to oppose to engage the public in science through storytelling (Dahlstrom & Scheufele, 2018; Kaplan & Dahlstrom, 2017):

1. Stories are perceived as subjective and therefore may distort the objective nature of science;
2. Stories are often related to fiction;
3. Stories might be persuasive, but do not have to provide evidence to support claims;
4. Stories can mislead people in believing content without careful scrutiny.

Contrary to the opinions of the latter, it should be remembered that the purpose of storytelling is offering a clear, true, and convincing description of real events. Scientific communication through storytelling is the process of refining the most prominent information from a complex system to benefit from its exposure to the public who otherwise would not be exposed to this information. A scientific storyteller should not change the truth by distorting evidence and should distill the story that the evidence tells (ElShafie, 2018).

Research Goal

Our goal was to investigate the motives of non-scientific participants to participate in online scientific lectures through storytelling and explore the implications of the stories on the participants.

Methodology

The study employed a mixed-methods approach. In the quantitative aspect, participants answered an online questionnaire that included three sections: (a) general personal details; (b) a rating statements using the Likert scale, which examined motives for attending lectures; and (c) the general opinion of the participants on

the lectures. In the qualitative chapter, semi-structured interviews were conducted with 10 participants.

Research Context

At the beginning of the COVID-19 quarantine, the Department of Science and the Center of Education for Environmental Sustainability initiated online lectures for non-scientific participants designed to expose participants to scientific issues through storytelling. This is part of the Agenda of Kibbutzim College of Education Technology and the Arts—to open its gates to a diverse audience. The project included 20 lectures held twice a week via Zoom during a three-month period. On average, every lecture included 80 participants.

Research Population

The research population (N = 151) was heterogeneous in terms of age, level of education, geographical distribution, and areas of interest.

The Quantitative Questionnaire

The quantitative questionnaire included 17 questions that were divided into four sections to check the participants' motivation to join the online lectures. The first section of questions addresses motivation for attending lectures arising from the need to acquire knowledge (Cronbach's alpha = 0.715). The second section refers to motivation for attending lectures arising from the need for entertainment (Cronbach's alpha = 0.751). The third section addresses motivation for attending lectures stemming from the need for social relationships (Cronbach's alpha = 0.653). And the last section addresses motivation for attending lectures stemming from desire for nature (Cronbach's alpha = 0.572).

Semi-structured interview. Semi-structured open-interviews were conducted as part of the qualitative section. The interviews allowed exploring certain topics with the help of a defined protocol while allowing flexibility. The interviewer can clarify various issues that arise from the interviewee's responses while linking issues that she/he is interested in researching (Fossey et al., 2002). The initial reference to the interviewees was made via Zoom and through the project's Whats App group.

Data analysis. The interview context was transcribed and analyzed. The analysis included preliminary analysis division of the entire text into inductive categories and secondary analysis division into sub-categories, and ascribing it to interviewees' quotations. The interviews were analyzed by the two researchers independently. A 95% agreement was found in the division into the various categories. In the quantitative section, we conducted a statistical examination by using T-tests, F-tests, and also descriptive statistics.

Findings

Quantitative Findings

Background variables. The online questionnaire was answered by 151 respondents: 96 women (63.5%), 46 men (30.5%), and nine who did not answer the question (6.0%). Of the respondents to the questionnaires, 72 defined themselves as engaged in education (47.6%), compared with 70 who defined themselves as not engaged in education (46.4%) and nine who did not answer the question (6.0%). Eighty-three of the participants had a bachelor's degree or higher (54.9%), 23 respondents had a high-school education (15.2%), 21 respondents had a middle and elementary school education (13.9%), four respondents were preschoolers (2.7%), and 20 participants did not answer the question (13.3%). Of the respondents, 61 defined themselves as having a scientific background (40.4%), 81 participants defined themselves as not having a scientific background (53.6%), and nine who did not answer the question (6.0%). Respondents were divided into four age groups: 21

participants were aged 0-19 (14.0%), 33 participants aged 20-40 (21.7%), 52 participants aged 41-60 (34.5%), and aged 61 and over (29.8%). The values of the motives for participating in the online lectures were relatively high (see Figure 1).

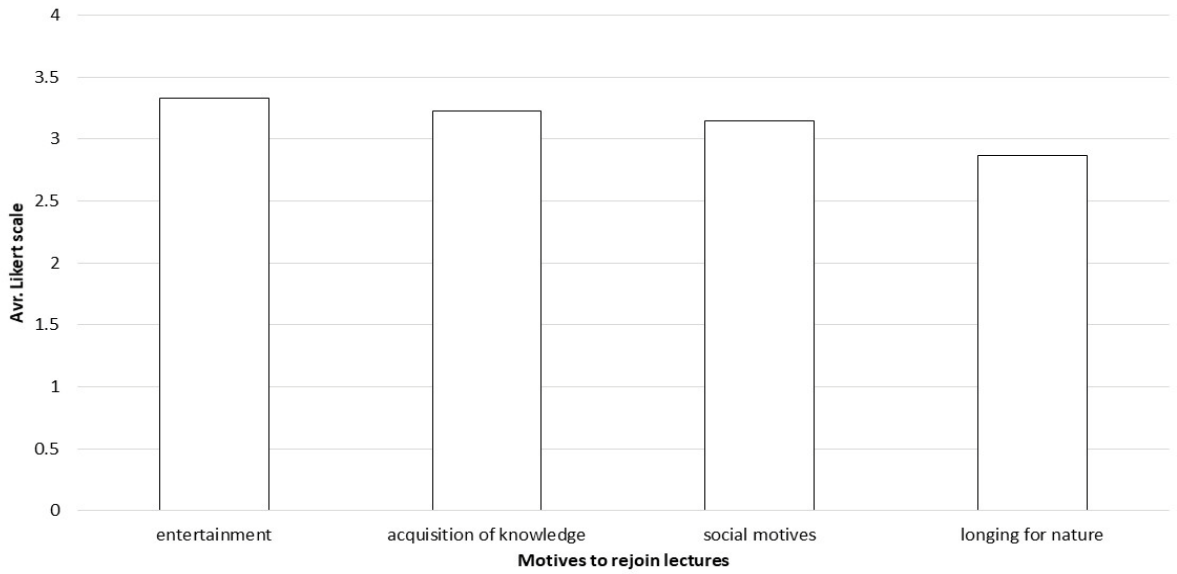

Figure 1. The average of Likert scale questionnaire of rejoining the lectures.

Motives for attending lectures. The questionnaire's findings indicate why the participants returned to the online lectures (see Figure 2). The first reason was the topics of the lectures. The second reason was the way that the lectures were conducted. The third reason was the graphics and information in the presentation. And the fourth reason was the interaction of the lecturer with the participants.

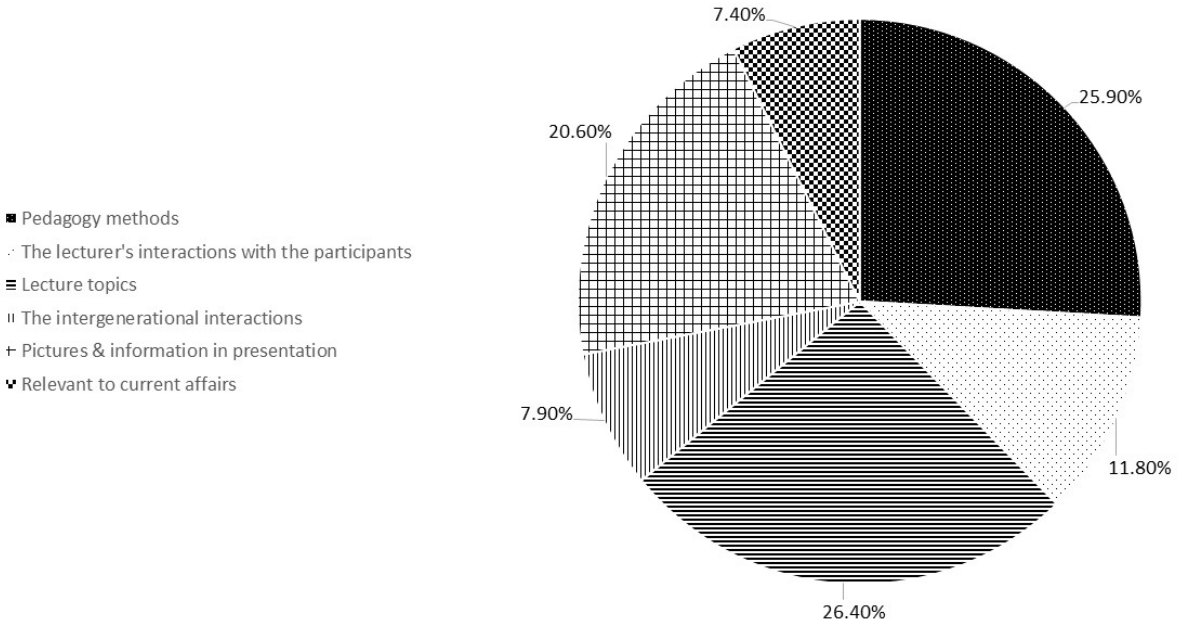

Figure 2. Percentage of reasons for which participants returned to listen to lectures.

***T*-test.** The quantitative analysis shows that only in the variable of "longing for nature" is there a significant statistical difference ($t = 2.895$; $P = 0.005$) between a population that defined itself as engaged in education versus a population that does not engage in education. In the other three variables representing different motives for the participants' rejoining the lectures, "acquisition of knowledge," "entertainment," and "social motives," no significant statistical difference was found ($P > 0.05$) among these populations. Also, no significant statistical difference was found between participants that defined themselves as having a background in science and those who defined themselves without a background in science in all four defined motives.

***F*-test.** In the *F*-test, it was decided not to address the younger participants. Hence, the *F*-test examined the motives of three age groups: aged 20-40 (25.2%), aged 41-60 (40.3%), and participants over the age of 61 (34.5%). *F*-test results show that only the social motive possesses a significant statistical difference among the three groups ($F = 5.703$; $P = 0.004$). In order to examine which group is different from the other two in the values of social motives, a Scheffe POST HOC test was conducted. The results indicated that the motives of the older group joining the online lectures was not a social motive, unlike the other two groups' motives that also include the social motive.

Qualitative Findings

The inductive qualitative analysis indicates two main sections. The first is related to the conduct of the lecturer. At this level, three main themes were found that emerge from the interviewees' statements. Here, participants describe which points in the lecturer's conduct influenced them to continue their participation in online lectures that dealt with various topics of nature focusing on animals. The first theme includes the scientific knowledge imparted in the lectures. Participants address in this theme the breadth and depth of the scientific information conveyed as part of the lectures. The second includes the connections drawn between flora and fauna and other areas of knowledge while creating the multidisciplinary human context. The topic emerges from the participants' remarks and illuminates the lecturer's ability to connect scientific information with areas outside the biological world but related to the participants' reality. The third theme relates to pedagogy. The participants testified that mode of pedagogy used fostered the public's connection to the scientific issues.

The second section describes the influence of the lecturer's conduct on the online lectures, for which two major themes were found: The first describes the participants' positive feeling of the online lectures. The second theme includes the message conveyed by the online lecture though it is implied and not explicit.

Based on these two sections and main themes found in each section, the findings will be presented.

First section—The conduct of the lecturer. As mentioned, this section includes three main themes. The first theme is the personal scientific of the lecturer. The second theme is the links created by the lecturer between the scientific issues and the multidisciplinary human context of the public everyday life. The third theme is called "teaching-learning processes" (pedagogy). This theme has three categories: teaching methods, humor as a pedagogical tool, and technological tools.

Knowledge acquisition. The participants mentioned the lecturer's wide-scale scientific knowledge. For example, "You could see how knowledgeable he is," or "The lecturer is well versed in the material." Participants were able to appreciate the lecturer's extensive knowledge in the field he presented during the lectures, as one participant described: "The knowledge presented during the lectures cannot be acquired in

books." The distinction of the extent of the lecturer's knowledge was also recognized by young listeners, as a mother quoted her 11-year old: "Mom, […] I could not read it in any book. These are things could be told only by a wise man with great knowledge and experience … it seems he has seen many things." The girl describes the important combination of extensive knowledge based on experience and depth in the areas of scientific knowledge or as she describes "has seen."

Another participant describes how the lecturer combined scientific knowledge through different points of view: "Going from the macro to the micro … there is structure in the lecture; you can follow his train of thought." It can be assumed that the participant claimed that the connections between the macro-level of the discussed scientific issue and the micro-level helped understand the scientific phenomena described. The link between macro- and micro-requires a level of knowledge that enables navigation. Another participant, who testifies that she travels and possesses environmental knowledge, noted that she acquired additional knowledge in the lectures: "I learned a lot during every lecture. I've traveled a lot … I've heard and seen many things … and yesterday I wrote to my friends—'You don't know how much you don't know'." This participant describes the knowledge she surprisingly acquired during the lectures. She notes that although she traveled and experienced the outdoors and met animals, she was surprised by the lecturer's ability to refresh her knowledge. In conclusion, it can be said that the participants appreciated the scope of the lecturer's knowledge and understood that this knowledge "does not exist in books." The participants made this distinction regardless of their age and scientific background.

The multidisciplinary human context. The participants in the lectures emphasized how scientific knowledge is woven into the human context. In fact, participants described how the lecturer was able to "weave" scientific knowledge into explanations related to everyday life. One participant described it as following: "Even if I read about an animal's life or another [I will not know] the intriguing content … that the lecturer adds ... he personifies animals … It's like looking at ourselves through the animals. It's amazing, intriguing, and enriching." The participant testifies that the way the lecturer introduces the issues allowed her to look "in the mirror" at humankind through the animals mentioned. Another participant described "looking in the mirror" in the following words: "We can learn about our society by looking at animals. It's like a parable. Through the animals, we discover ourselves." Both participants valued using animals as a bridge between the scientific knowledge imparted and humankind. This human context was also described by another participant: "His explanations, his anecdotes […] about fatherhood in nature make it more interesting." The participant states that the connection to scientific topics is the added value which makes science more interesting. Another participant knew how to focus on the importance of linking scientific knowledge about animals to her everyday life: "[The lecturer] organizes my thoughts, like a story. I remember many of the things he said. I remember those stories about the animals, as I remember stories related to my life, or things that are revealed to me about this world." One participant described the feeling of scientific knowledge accessibility well: "[…] it's not so vague that one can't touch and hear it. It's described as if it's in front of your eyes." The examples above illustrate the importance of mediating scientific information and connecting it to human life while describing animals' lives. The lecturer also related political issues to the lectures. For example, the lecture on "Leadership in Nature" was held on the day the Israeli Prime Minister's indictment was read out in court. One participant described it: "The last lecture on leadership … it was so striking and related to the day's current affairs; it tells us something about ourselves, coordinated beautifully." In addition, one participant noted the importance of creating an overall picture and not just focusing on scientific knowledge: "I like that the lecturer talks about the

topics broadly ... he knows a lot. And he creates a channel that includes interdisciplinary integration. If ... he teaches something from biology, but it relates to another discipline that explains the biological issue, he will explain that, too. Even if it's not really biology." From this, the importance of connecting scientific knowledge and the human world around us is apparent. In summary, the lectures bridged science and the participants without a scientific background.

Teaching-learning processes (pedagogy). When planning a teaching unit, the lecturer examines the options available in order to achieve his goals. These goals vary and may include, for example, cognitive, social, moral, emotional, etc. The lecturer chooses teaching tools and methods that will serve his goals and suit his audience. In this section, we will discuss the two choices made by the lecturer, as reflected from participants. The first part of this chapter will address the teaching methods and the second part will address the tools used.

Teaching methods. In the chapter on teaching methods, the participants addressed two integral points. The first was storytelling, and the second was combining humor. The way scientific knowledge was transferred received much attention by the participants. They compared the scientific-knowledge transfer methods in these lectures to methods used in other scientific lectures they had attended. A number of participants identified that the scientific knowledge transferred was via storytelling: "He is a really good storyteller" or "It is interesting to listen to him. It's like a story." Another participant also used the word "story": "His style is fascinating. Like fairytales." But the use of the story method did not prevent the participants from acquiring knowledge: "It's not as though I was listening to a lecture by someone who is all 'scientific' and uses scientific jargon. Obviously, he does, but it's different". The participants testify that the lectures deepened their understanding of scientific aspects while acquiring new scientific knowledge: "He is a talented storyteller. I mean… a talented teacher." It is evident that the integration of storytelling in the lecture was an effective tool for this participant who is one of many examples. Another participant expounded: "This is basically 'gossip' about nature. Humans like to hear tales, and 'gossip' about plants and animals .... that's what makes the difference ... to spice things up. And that's good." Another characteristic that the participants noted was the interaction between the lecturer and the participants: "There is a certain dynamic in audience involvement." This dynamic is unfamiliar in commonly delivered scientific lectures. Another example is exemplified by an interviewee who was impressed with the connection formed between the lecturer and a 9-year-old girl, who took charge of the live chat during the lectures. The girl's role to read the participants' questions aloud. The girl was given the authority to assist in the management of the lecture. Such collaboration between a lecturer and a child is not recognized in other lectures: "Especially the connection with the girl… it was very special. It intrigued me." One of the participants lecturers concluded the lecturer's teaching methods as follows: "He also speaks in a very interesting way. Last time, he offered to share with us his presentations. The combination of the presentations with his stories, his additions, that's the essence … the stories he tells about each picture, that's what makes it fascinating."

Humor as a pedagogical tool. The humor used during the lectures was often noted by the participants and contributed on several levels. The first: "This is not a dry lecture, but a personal one with a lot of humor." On one hand, humor, in this case, helped neutralize the familiar "dryness" from other scientific lectures. Moreover, the incorporation of humor in the lectures increased the familiar atmosphere created during the lectures even though on average about 80 participants were present. Hence, humor helped engage the public in science by creating a sense of camaraderie between the lecturer and the participants. Another usage of humor has to do with alleviating tension among the participants: "Humor is a tool that helps break the tension a bit. A person requires a lot of mental strength to listen, and persist in listening. When a joke is told, it releases the tension…

it's fun." The participant described the need for constant concentration throughout the lecture, in order to fully understand the issue in discussion. Therefore, humor incorporated during lectures creates a short break allowing the participants comic relief. This pause helped to further follow up the lecture's topic. Other participants also noted that humor caused enjoyment without specific reasons: "The lecturer's humor makes the lectures cheerful and enriching." The humor also helped to raise the curiosity: "The sense of humor ... it is amazing, intriguing, and enriching." In conclusion, it can be said that a combination of humor in lectures as part of the scientific content aided in creating openness, enabling enjoyment, and curiosity towards the scientific topics conveyed in the lecture.

The following quote may summarize this theme: "… all wires into one piece tied together. Just wonderful." In other words, it can be said that in delivering lectures through stories, the participants were able to acquire scientific knowledge and deepen their existing knowledge of scientific concepts. In addition, speaking science through stories helped create a direct connection between the lecturer and the participants.

Technological tools. Participants were ambivalent about the use of technology that was the basis for online lectures. Participants mentioned positively the way the lecturer used the screen as one participant described: "... I have connected to conferences from home, even professional, but they were not at such a high level. The lecturer utilizes the screen very effectively." This participant is not the only one who described the richness of the presentations. 64.5% of the respondents to the questionnaire stated that one of the reasons they returned and participated in the online lectures was due to the graphic presentations. One of the characteristics of the presentations in these lectures is the use of large, high-quality images spread across the entire screen with little, if any, text. The graphics in the presentations formed the basis for the scientific explanations as one of the participants described: "The combination of the presentations with his anecdotes is what makes it interesting and fascinating." It is evident that the participants appreciate the presentations' design, which depicts nature. Some participants also critiqued the way the lecturer used the technology, especially the audio usage of the zoom system. Quite a few participants, more than once, sought to silence all participants in order to prevent background noise: "Not all participants were silenced and there was background noise." Others argued that the problems stemmed from unskilled zoom users: "So, the 'oldies' who are not used to operating zoom were noisy." Other complaints related to asking questions during the lecture: "There are those who interrupted and disturb the lecturer with questions and this interferes with the flow of speech." Although some of the participants did not like the loose atmosphere which allowed the participants to speak freely, there were other voices as well: "It was great that the kids were able to ask questions … the questions they asked were the questions I wanted to ask but I didn't have the guts." This quote is indicative that the integration of the children during the lecture by way of asking questions contributed to the lectures. In conclusion, it can be said that the lecturer used the digital media in a manner that served his goal-engaging the public with a scientific issue. Also, the lecturer's decision to allow speech during the lecture may have disturbed some of the participants, but encouraged a direct connection between the lecturer and the participants.

Second level—Products. At this level, in which the products originating from participation in lectures are described, two main themes are presented: The first theme is the personal involvement of the participants during the lectures. And the second theme is the hidden message conveyed in the lectures and how the participants perceived it in the lectures.

Emotional involvement. Participants expressed a wide range of emotions that contributed to the pleasant atmosphere created in the lectures, which were completely different from scientific conferences. Participants

used expressions of positive emotions, such as “fascinating,” “fun,” “pleasant,” “wonderful,” “relaxed,” “excellent,” and “delightful.” Emotional involvement included a number of areas. There were participants who simply enjoyed learning: “I just love discovering things that make sense in this world.” There are those who stated that they liked the notion of learning without the test at the end: “I don’t need a test in order to learn more.” Another participant said, “For me it’s a way to learn. Otherwise I wouldn’t. It contributes a lot.” From these quotes, it can be learned that the positive emotions promote learning the scientific knowledge, and for some, it was even the only way to be exposed to the scientific research. Other participants incorporated emotional involvement in the lectures as part of the intergenerational encounter: “When it’s with kids it’s even more fun.” It can be assumed that the lectures formed the basis for extending the time in which representatives of different generations convened, which would probably not have been possible without lectures. The combination of enjoyment and intergenerational encounter that contributes to the acquisition of knowledge can be found in the following quote: “It was an opportunity for all of us to enjoy and develop knowledge about the environment in which we all live. It is great to make knowledge accessible to the general public and children.” It can be understood that the participants enjoyed expanding their knowledge with all the listeners without any difference among generations. Another aspect expressed by some participants is the ability to listen to the lectures at home as written in one feedback. “It’s a great that it is delivered straight into our house. It becomes a part of life. We host the lecturer in our living-room.” In one of the interviews this was mentioned: “The conversation is pleasant, it’s informal.” In conclusion, it can be seen that the participants made use of a wide range of positive expressions and emotions to emphasize their positive involvement during the lectures.

A message. The message conveyed in the lectures, overtly or covertly, was perceived by the participants. The lectures were structured in the form of a parable and moral. Although the moral was not explicitly presented as “developing awareness of nature conservation,” “developing affinity towards nature,” and “developing an understanding that humankind is a part of nature,” the participants understood it. Each of the interviewees pointed out the things that were close to his heart. For example, “[The goal is] environmental responsibility ... understanding the impact of mankind on the environment.” The human impact on the environment can also be found in the following quote where the participant more clearly stated: “That we are all part of one eco-system. Including bacteria, parasites, and all of us and we cannot be separated even if we really want to.” Another example of understanding the moral is described regarding a lecture that dealt with the lesser kestrel (LK). During the lecture, the participants were exposed to the negative effect of the myna, which is an invasive species, on the LK: “The lecture about the LK was very significant for me; we should not harm the myna.” Although the myna harms the LK, the participant realized that it was the human’s fault, as people brought the myna from Southeast Asia to Israel and set them free.

Man’s connection to nature can also be found in the following quote: “The most interesting part of the lecture was the understanding of our impact on nature and our ability to influence the current situation.” In this case as well, it can be understood that the participant realized the lecture’s purpose, which was to raise awareness regarding the impact of humans on the environment. Another goal participants pointed out is encouraging participants’ desire to help the environment and reduce human impact on nature, as in the following: “I think every lecture contains a message that we should be more considerate towards our environment, as it’s a gift we received and shouldn’t destroy it. It was never said explicitly during the lecture... but it was there. Whoever joins to the lectures already knows: we are an integral part of what happens around us and we need to know what is harmful and what we can do to respect nature, how to educate the next

generation to live on a planet with such a rich variety of animals and plants. It is disappearing." This participant states that the hidden goal is nature conservation, as the first stage of this goal is to bring nature closer; the second stage is to increase awareness; and the third stage is to encourage action towards nature conservation.

To summarize our findings in this chapter, there are two levels of reference presented by the participants. The basic level includes the way the lecturer conducts the lecture. The unique way the lectures were delivered made it possible to create a listening experience and an understanding of the message that the lecturer desired to convey in the lectures. The experience and message conveyance are the second level, built, as mentioned, on the basis of the first level. These two levels form the basis of a pyramid, in which two additional levels will be detailed in the discussion (see Figure 3).

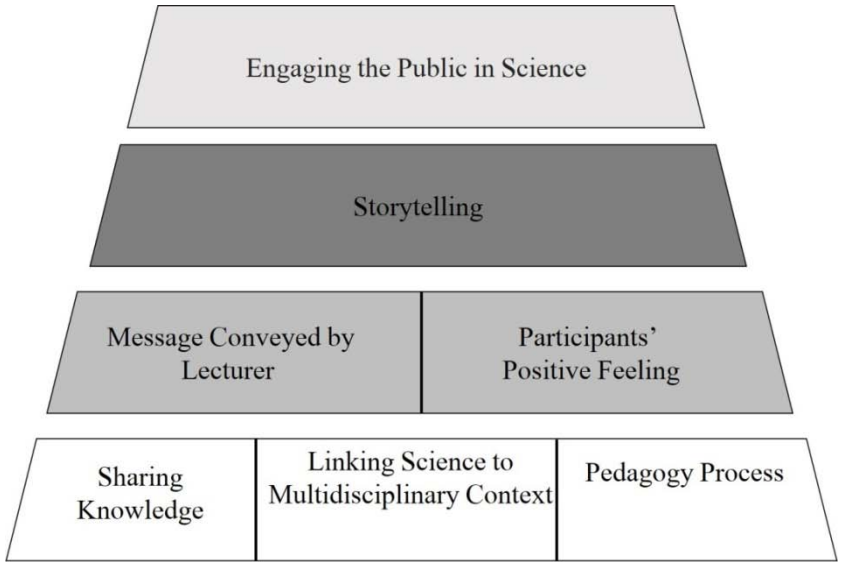

Figure 3. A learning model based on storytelling to link people without a scientific background to scientific topics.

Discussion

During the COVID-19 quarantine, teachers were occupied with the question of how to handle the remote teaching. What are the factors that encourage the free auditor with no scientific background to re-join scientific lectures? From the findings, a pyramid-like shaped model (see Figure 3) was constructed. We propose that adoption of this model (detailed below) could form the basis for online teaching. Although this model was built on the basis of scientific lectures, the model does not depend on a particular discipline, and the lectures' subject could be transformed into any other discipline.

The basis of the model, as expressed in the findings, describes the importance of three points to which the lecturer engaged in online teaching should pay attention. The first is the transfer of knowledge by the lecturer, the second is the multidisciplinary human context, and the third is teaching-learning processes. Participants pointed out that during the lectures those three points were taken under account. After the implementation of the three detailed points, the second level of the model (see Figure 3) which includes emotional involvement of the audience and conveying the message positively. The connection between emotions and cognitive aspects is familiar from the literature. Positive emotions help promote cognitive ideas (Lugmayr et al., 2017) and create connections between scientists and the public (Baram-Tsabari & Osborne, 2015; Joubert et al., 2019). Based on these two phases of the pyramid outlined in the findings, the third level was constructed—storytelling (see

Figure 3). Storytelling was an unconscious choice of the lecturer for the purpose of conveying the message. In fact, the analysis of the participants' interviews and the questionnaires revealed that the lecturer used a "storytelling event" method which was perceived by the participants as empathetic skills which are required to engage an audience (Bray, France, & Gilbert, 2011).

In a storytelling event, the lecturer revamps the text during the event while examining the relationship with the listeners. As a result, though every storytelling event may be performed differently each time, it is within a fixed framework. In this study the storytelling event was the topic of the various lectures which were included under one framework called "Sanity during COVID-19—What Does Nature Tells Us?" The message in a storytelling event may be conveyed explicitly or in an implicitly, as the lecturer/storyteller uses at least three channels of communication with the listeners: the language of speech, intonation, and movement. In the case of this study, participants testified that the lecturer did indeed convey the message sometimes explicitly and implicitly via the use of the various communication channels, which helped convey the message (Baram-Tsabari & Lewenstein, 2017). In this study, the goals of the lectures were implicit, but the audience still understood it. The participants mentioned the pictures in the presentation and the lecturer's humor as important tools. This choice of method is recognized from the literature as helpful in conveying a scientific message (Drummond, 2020; Riesch, 2015; Yeo, Anderson, Becker, & Cacciatore, 2020). All of these have been incorporated as part of a storytelling methodology that effectively conveys the message, as is also recognized in the literature (Bray et al., 2011; Yaghoubi & Shaeri, 2019).

Storytelling, the third level in the model, is one way to create the bridge between science and the public. Through storytelling, knowledge produced in academia can be shared with the general non-scientific public (Martinez-Conde & Macknik, 2017). Even the most complex concepts in science can be conveyed to the public through storytelling (ElShafie, 2018). Stories provide unique ways to connect science with the human experience. In the case of this study, the human context is multidisciplinary, as detailed in the findings section. Stories help people understand complex concepts and make science more relevant to their lives (Riedlinger et al., 2019), which, in the case of this study, is emotional involvement. Unlike science, one of the characteristics of storytelling is the combination of emotions in order to make the story meaningful. Emotional meaning is critical to effective scientific communication (ElShafie, 2018), as in the case of this study, the message. Stories succeed in getting people to change their behavior (Haigh & Hardy, 2011) and ignite an interest in a specific subject (Cormick, 2019; Joubert et al., 2019), in this case the fourth level of the model, connecting people to science. As many of the participants mentioned, storytelling allowed them to understand the message conveyed, even if it was not explicit.

As stated, the model can also be converted to additional disciplines based on the history of the stories. In the past, storytelling was been used to convey wisdom, knowledge, and culture and to strengthen social ties since the earliest periods of human existence (Cormick, 2019). Ancient societies have gathered around bonfires telling stories, allowing our ancestors to share cultural information and infuse meaning into their shared experiences (Joubert et al., 2019). Hence, as stated, the model can also be used in other disciplines.

Pedagogically, the use of storytelling is a means of increasing motivation for learning (Miller & Pennycuff, 2008), raising awareness (Riedlinger et al., 2019), helping to change attitudes (Dahlstrom & Scheufele, 2018), and inspiring (Riedlinger et al., 2019). Storytelling increases listeners' likelihood to remember information (ElShafie, 2018), reduces objections, is more compelling than presenting uninterrupted data and increases engagement when passing on information to non-expert audiences (Cormick, 2019). Storytelling also helps to

harness people to environmental conservation activities (Riedlinger et al., 2019) or to change other behaviors (Dahlstrom & Scheufele, 2018). Neurological and physiological effects are also known as a result of storytelling. For example, storytelling causes the secretion of hormones, which increases concentration and attention span (ElShafie, 2018).

Participants testified that online storytelling was able to bridge the gap between "dry science" (Pollock & Bono, 2013) and participants with no scientific background. Through storytelling, participants acquired scientific knowledge, connected with nature and science and were even encouraged to engage in future environmental issues which can be part of the science education (Golumbic, Fishbain, & Baram-Tsabari, 2020; Riedlinger et al., 2019). The motives for which participants continued to take part in lectures through storytelling included emotional aspects, affinity to the topics and how the story was presented. The way it is presented has a great impact on creating a permanent listener community (Coskie et al., 2010), connecting them to nature and science, and exposing them to diverse topics that would not otherwise be available to them.

In this study, the lecturer communicated with the audience. This type of communication is consistent with the characteristics of science communication (Bray et al., 2011), designed to bring the audience with no scientific background to engage in scientific topics. In conclusion, the model described in this article based on the storytelling methodology that helped bring listeners without a scientific background closer to the various scientific topics, can be another tool for scientists interested in fostering public engagement in science and may be incorporated in programs designed to make science accessible to the public (Baram-Tsabari & Lewenstein, 2017).

Limitations

The study has a number of limitations related to the research model, tool, and research sample as it is a pioneering study and due to the lack of existing research tools for examination of the questionnaire. The model was yet to be examined in other disciplines. The study used a tool that was developed for the current study and was yet to be examined in other studies. The sample of the study included only 150 participants.

Conclusions and Recommendations

At the theoretical level, the research has expanded knowledge regarding the methods to engage non-scientific public in science. The study also developed a theoretical model for online teaching. The study did not confine itself to individual treatment of a homogeneous population, but examined a heterogeneous group (age, gender, and background). The study added knowledge that may help understand the barriers that make it difficult for scientists to share their knowledge to the public. At the applied level, research findings have a significant contribution to the pedagogical field and for the development of new teaching methods in the online medium.

Storytelling methodology connects a heterogeneous audience with lack of scientific background to science. Through the use of the storytelling method, the audience can connect to content that is unfamiliar, while creating an emotional bond with the participants and a unique learning experience. We believe that the model presented in this study for the field of science may apply for additional disciplines.

Declaration of Conflicting Interests

The authors declare no conflicts of interest with respect to the authorship and/or publication of this article.

References

Baram-Tsabari, A., & Lewenstein, B. (2017). Science communication training: What are we trying to teach? *International Journal of Science Education, Part B, 7*(3), 285-300. https://doi.org/10.1080/21548455.2017.1303756

Baram-Tsabari, A., & Osborne, J. (2015). Editorial bridging science education and science communication research. *Journal of Research in Science Teaching, 52*(2), 135-144. https://doi.org/10.1002/tea.21202

Bray, B., France, B., & Gilbert, J. K. (2011). Identifying the essential elements of effective science communication: What do the experts say? *International Journal of Science Education, Part B*, 1-19. https://doi.org/10.1080/21548455.2011.611627

Cormick, C. (2019). Who doesn't love a good story?—What neuroscience tells about how we respond to narratives. *Journal of Science Communication, 18*(5), 1-10. https://doi.org/10.1017/CBO9781107415324.004

Coskie, T., Trudel, H., & Vohs, R. (2010). Creating community through storytelling. *Talking Points, 22*(1), 2-9.

Dahlstrom, M. F., & Scheufele, D. A. (2018). (Escaping) the paradox of scientific storytelling. *PLoS Biology, 16*(10), 7-10. https://doi.org/10.1371/journal.pbio.2006720

David, Y. B. Ben, Garty, E. S., & Baram-Tsabari, A. (2020). Can scientists fill the science journalism void? Online public engagement with science stories authored by scientists. *PLoS ONE, 15*(1), 1-15. https://doi.org/10.1371/journal.pone.0222250

Drummond, C. (2020). Emotion and judgments of scientific research. *Public Understanding of Science, 29*(3), 319-334. https://doi.org/10.1177/0963662520906797

ElShafie, S. J. (2018). Making science meaningful for broad audiences through stories. *Integrative and Comparative Biology, 58*(6), 1213-1223. https://doi.org/10.1093/icb/icy103

Fischhoff, B. (2019). Evaluating science communication. *PNAS, 116*(16), 7670-7675. https://doi.org/10.1073/pnas.1805863115

Fossey, E., Harvey, C., McDermott, F., & Davidson, L. (2002). Understanding and evaluating qualitative research. *Australian and New Zealand Journal of Psychiatry, 36*(6), 717-732. DOI: 10.1046/j.1440-1614.2002.01100.x

Goldberg, H., & Hanlon, C. (2019). When I say … the knowledge paradox: The more I know, the less I can clearly explain. *Medical Education, 53*(1), 13-14. https://doi.org/10.1111/medu.13638

Golumbic, Y. N., Fishbain, B., & Baram-Tsabari, A. (2020). Science literacy in action: Understanding scientific data presented in a citizen science platform by non-expert adults. *International Journal of Science Education, Part B.* https://doi.org/10.1080/21548455.2020.1769877

Green, S. J., Grorud-colvert, K., & Mannix, H. (2018). Uniting science and stories: Perspectives on the value of storytelling for communicating science. *FACETS, 3*, 164-173. https://doi.org/10.1139/facets-2016-0079

Haigh, C., & Hardy, P. (2011). Tell me a story—A conceptual exploration of storytelling in healthcare education. *Nurse Education Today, 31*(4), 408-411. https://doi.org/10.1016/j.nedt.2010.08.001

Joubert, M., Davis, L., & Metcalfe, J. (2019). Storytelling: The soul of science communication. *Journal of Science Communication, 18*(5), 1-5.

Kaplan, M., & Dahlstrom, M. F. (2017). How narrative functions in entertainment to communicate science. In D. Kahan and D. Scheufele (Eds.), *Oxford handbook on the science of science communication* (pp. 311-319). Oxford, UK: Oxford University Press.

Katz, Y. (2013). Against storytelling of scientific results. *Nature Methods, 10*(11), 1045. https://doi.org/10.1038/nmeth.2699

Llorente, C., Revuelta, G., Carrió, M., & Porta, M. (2019). Scientists' opinions and attitudes towards citizens' understanding of science and their role in public engagement activities. *PLoS ONE, 14*(11), 1-20. https://doi.org/10.1371/journal.pone.0224262

Lugmayr, A., Sutinen, E., Suhonen, J., Sedano, C. I., Hlavacs, H., & Montero, C. S. (2017). Serious storytelling—A first definition and review. *Multimedia Tools and Applications, 76*(14), 15707-15733. https://doi.org/10.1007/s11042-016-3865-5

Lutz, S. R., Popp, A., Emmerik, T. Van, Gleeson, T., Kalaugher, L., Möbius, K., Mudde, T., Walton, B., Hut, R., Savenije, H., Slater, L. J., & Solcerova, A. (2018). HESS opinions: Science in today's media landscape—Challenges and lessons from hydrologists and journalists. *Hydrolgy and Earth System Sciences, 22*, 3589-3599.

Martinez-Conde, S., & Macknik, S. L. (2017). Finding the plot in science storytelling in hopes of enhancing science communication. *Proceedings of the National Academy of Sciences of the United States of America, 114*(31), 8127-8129. https://doi.org/10.1073/pnas.1711790114

Miller, S., & Pennycuff, L. (2008). The power of story: Using storytelling to improve literacy learning. *Journal of Cross-Disciplinary Perspectives in Education, 1*(1), 36-43.

National Academies of Sciences Engineering. (2016). *Communicating science effectively: A research agenda*. https://doi.org/10.17226/23674

Pollock, T. G., & Bono, J. E. (2013). Being scheherazade: The importance of storytelling in academic writing. *Academy of Management Journal, 56*(3), 629-634. https://doi.org/10.5465/amj.2013.4003

Riedlinger, M., Metcalfe, J., Baram-Tsabari, A., Entradas, M., Joubert, M., & Massarani, L. (2019). Telling stories in science communication: Case studies of scholar-practitioner collaboration. *Journal of Science Communication, 18*(5), 1-14. https://doi.org/10.1017/CBO9781107415324.004

Riesch, H. (2015). Why did the proton cross the road? Humour and science communication. *Public Understanding of Science, 24*(7), 768-775. https://doi.org/10.1177/0963662514546299

Rodder, S. (2011). Science and the mass media—"Medialization" as a new perspective on an intricate relationship. *Sociology Compass, 5*(9), 834-845.

Sharon, A., & Baram-Tsabari, A. (2013). Measuring Mumbo-Jumbo: A preliminary quantification of the use of jargon in science communication. *Public Understanding of Science, 23*(5), 528-546. https://doi.org/10.1177/0963662512469916

Valinciute, A. (2020). Lithuanian scientists' behavior and views on science communication. *Public Understanding of Science, 29*(3), 353-362. https://doi.org/10.1177/0963662520907001

Weingart, P., & Joubert, M. (2019). The conflation of motives of science communication—Causes, consequences, remedies. *Journal of Science Communication*, *18*(3), 1-13.

Yaghoubi, M., & Shaeri, J. (2019). Review of storytelling characteristics in architecture education. In *The 6th Iran International Conference on Engineering Education*, Mashad.

Yeo, S. K., Anderson, A. A., Becker, A. B., & Cacciatore, M. A. (2020). Scientists as comedians: The effects of humor on perceptions of scientists and scientific messages. *Public Understanding of Science, 29*(4), 408-418. https://doi.org/10.1177/0963662520915359

Zabel, J., & Gropengießer, H. (2015). What can narrative contribute to students' understanding of scientific soncepts, e.g., svolution theory? *Journal of the European Teacher Education Network, 10*, 136-146. http://jeten-online.org/index.php/jeten/article/view/74/63