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# Delivering Effective Science Communication: Advice from a Professional Science Communicator

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## Abstract

Science communication is becoming ever more prevalent, with more and more scientists expected to not only communicate their research to a wider public, but to do so in an innovative and engaging manner. Given the other commitments that researchers and academics are required to fulfil as part of their workload models, it is unfair to be expect them to also instantly produce effective science communication events and activities. However, by thinking carefully about what it is that needs to be communicated, and why this is being done, it is possible to develop high-quality activities that are of benefit to both the audience and the communicator(s). In this paper, I present some practical advice for developing, delivering and evaluating effective science communication initiatives, based on over a decade of experience as being a professional science communicator. I provide advice regarding event logistics, suggestions on how to successfully market and advertise your science communication initiatives, and recommendations for establishing effective branding and legacy.

# 1. Introduction

Science communication is not a new phenomenon. In the UK, the concept of scientists communicating their research findings to the public dates back at least as far as the early nineteenth century, when scientists such as Michael Faraday spent a considerable amount of time and money trying to popularise science. However, as an academic discipline science communication is a relatively new field, which in the UK has undergone three main stages [1, 2]: scientific literacy, Public Understanding of Science (PUS) and Public Engagement with Science and Technology (PEST). In moving through these three stages, the ideology of the communication of science has developed from a primarily deficit model (in which scientists try to 'fill' gaps in the knowledge of the public) into one which encourages two-way dialogue between experts (specialist scientists) and non-experts (e.g. the public and scientists from other fields).

Yet how aware of these developments are scientists who engage in science communication activities but who do not have an academic background in this discipline? It has been suggested there might even be gaps in understanding between the professionals (let's call them science communicators) that are doing the practical side of science communication and the professionals (let's call them social scientists) that are reflecting on the worth and effectiveness of such activities [1]. Part of this tension arises because of the lack of a common language. Already in this introduction I have used terminology such as *dialogue*, the *deficit model*, and *scientific literacy*, terms which may be alienating to scientists who are not grounded in science communication research. Even when merely describing the process of science communication, there can be several interpretations of the terms outreach, public engagement and widening participation depending on the context in which they are used [3].

It can be a confusing landscape to traverse, especially for the uninitiated scientist who is making their first inroads into science communication. As an anecdotal example, my own academic position (Senior Lecturer of Science Communication) often leads me feeling as though I have multiple science communication identities. Am I a social scientist who is concerned with fundamental concepts relating to how scientists can communicate their research more effectively? Or a professional science communicator who is concerned with raising the profile of science amongst a variety of diverse communities? Ultimately, I am a bit of both, which is of great benefit, as such a role allows me to apply any good practice learned in one identity when acting in another.

The purpose of this paper is to share, in understandable terms, my experiences from being a professional science communicator in the hope that it will help others with the development of their own coherent and effective science communication strategies.

## 2. Practical Advice

**2.1 Development of initiatives**

As explained in the editorial of this special issue (and elsewhere, e.g. [4]) , a good way to develop science communication activities towards momentum and impact is to embed them into an initiative with a clear long-term objective or vision. This can have many benefits, including the re-use of resources, the opportunity for interdisciplinary collaboration, and a higher likelihood that the initiative(s) will benefit the practicing scientists in their career and development. For the effective development of your own long-term, objective-driven initiatives consider the following points:

- *What and why are you trying to communicate?* These are the two most important questions when developing your science communication initiatives, and demand careful consideration. You might have a clear idea of the topic you want to communicate, but what is your aim, and what will you consider successful and effective communication? For example, you might want to develop a science communication initiative that explores the scientific achievements of famous female scientists, aiming to inspire a future generation of female scientists in the process.
- *Who are you communicating to?* It is extremely important to consider who your audience is, as the type of activity (see below), the reason for communicating, and the language that is used may differ considerably between different groups and even from person-to-person. For example, communicating the importance of antimicrobial resistance to a group of school children would require a different approach to communicating the same topic to nurses at a local hospital. This example also highlights how the public involves a broad spectrum of audiences, ranging from school children and teachers to policy makers and clinicians. In the development of your initiatives, it is vital to determine which group(s) you will be working with, and how your message is best tailored to their individual needs. In some instances, you may want to include several audience groups in your initiatives; this will require flexible and multi-layered approaches to be beneficial to all those involved.
- *What type of activity are you using?* There are many different types of science communication activities, which can be split into broad groups: traditional journalism (e.g. newspapers and radio), live or face-to-face events (e.g. public lectures, panel debates, science festivals), and online interactions (e.g. blogs, websites, videos, podcasts) [5]. This article is concerned mainly with the face-to-face events. Likely many of us have participated in science fairs or visited schools [26],  but there is still a large variety of activities to choose from, a selection of which are listed below along with some of their strengths and weaknesses:
    - a) Panel Debates: these involve asking several panellists to discuss a topic. They can suffer from their lack of genuine audience

participation, but are a very effective way of showing agreement / disagreement between scientists.

b) Science Festivals: these range from very discipline specific festivals with a few events catering for several hundred people, to multi-disciplinary festivals with hundreds of events for many tens of thousands; there are over 60 different festivals belonging to the UK Science Festivals Network alone [6]. Such festivals are a very useful way of potentially engaging with a large audience, often with a lot of marketing and other logistical support. As a note of caution, research has shown that science festival activities must be careful not to present science as something that is purely enjoyment-centric, and that they must strive to communicate a balanced account of what being a scientist actually entails. [7]

c) Science Busking: these take the form of a series of science street performances, where science is used to draw in a crowd and explain a topic to them, a little like a close-hand magic show for science. Science busking is incredibly portable and flexible, but does rely upon the skill of the performer, and can occasionally run the risk of wowing rather than explaining / discussing.

d) Book Clubs: small reading groups for interested parties to discuss the scientific accuracy (or not) of a chosen book. One such example is the Bad Bugs Book Club in Manchester [1]. Whilst these initiatives allow for detailed and in-depth discussions, they are normally limited in terms of audience numbers.

e) Citizen Science: these are activities that involve the public in scientific research, to varying degrees. They might involve gathering and processing data, or even analysing results. A good example of a successful citizen science project is Sea Hero Quest, which is a mobile game dedicated to helping global research into dementia [8]. Whilst citizen science projects are an excellent way to involve the public in actual scientific research, care must be taken to ensure that they are not just being treated as machines to 'crunch data.' Ideally all participants should be acknowledged for their work, and be beneficiaries of the research. If you believe that your project would benefit from a citizen science appaorach then you might consider getting involving the Zoouniverse, the world's largest citizen science platform. [9]

f) Workshops: organising a dedicated workshop in which different community groups can discuss their understanding and opinions of a scientific topic is an effective way for researchers to better understand the societal benefits and limitations of their research. Organising these workshops can be time consuming, but working with existing community groups can help to ensure that there is an engaged audience.

g) Citizen Juries: these involve members of the public, researchers and policy members coming together to deliberate on a topic, using scientific research, policy and expert opinion as evidence to decide on

the most effective set of recommendations for a topic. Such formalised events can be extremely resource intensive, but they are also an effective way of ensuring that actions will be taken that benefit the greatest number of people. For more details about Citizen Juries, Kinglsey Purdam from the University of Manchester has created a very useful resource [10]

This represents only a small selection of the different types of activities that are available for selection. The National Coordinating Centre for Public Engagement (NCCPE) [11] provides a still more complete list, but the type of activity that you ultimately decide on is limited only by your own imagination and skill set. For example excellent science communication outcomes can be reached through using comedy [12], art [13] or even poetry [14]. The most important thing to consider is whether the activity that you have planned aligns well with the topic of your initiative, and that it suits the audience you have in mind.

- *Is there a chance for two-way dialogue?* It is often very tempting to develop a science communication activity with the objective of imparting a specific piece of information or awareness to an audience. However, such an approach, no matter how interactive, can never be thought of as genuine two-way communication. Two-way communication implies that the scientists that are running the activities are also listening to and learning from the audience with which they communicate. An analogy of this would be an oral presentation at a scientific conference which triggers a comment by an audience member which might, in turn, have influence on the speaker's next iteration of their work. It would be poor practice to ignore constructive feedback and work purely in isolation. Likewise, science communication initiatives should work towards a model based on dialogue between scientists and the public [15], so that audiences will feel a greater ownership of, and hence interest in, the activity they are participating in. Notably, the scientist also stands to benefit from this dialogue, for example by learning about what is perceived as being important or where there are clear barriers in understanding. All the examples that are quoted in the above bullet-point list can be tailored to be two-directional in nature. For example, the topic of the panel debate could be determined by first discussing with a community group what specific areas of science they were interested in and/or would benefit from finding out more about. During the panel debate members of the community could also be invited on to the panel to give evidence based on their own lived-experiences, and to engage in a mutual discussion with the experts. After the debate, any issues that remained unresolved could be followed up, for example by a visit to a scientist's place of work for the community group or vice versa. Such an approach requires far more time and resources than simply setting up a traditional panel discussion with several different experts from your institute, but the impact will be far greater and potentially much more meaningful to all those involved.
- *Are you re-inventing the wheel?* It is advisable to search the web or ask around locally whether anybody else has done something that suits your

activity, or is planning to do so in the future. Collaborating, or at least being aware of what has gone before, can help to speed up the road to effective delivery by saving you time invested in development, helping you to avoid potential pitfalls and allowing you to build on the experiences of others. The use of existing materials will also save time and money, which can then be better spent on other resources or an effective evaluation strategy (see Section 2.5). As well as doing a literature search, it is worthwhile asking the community for advice. The PSCI-COM (psci-com@jiscmail.ac.uk) and NCCPE-PEN (NCCPE-PEN@jiscmail.ac.uk) mailing lists in the UK are a great network for this, whilst the Public Communication of Science and Technology (newtwork@lists.pcst.co) offers a useful resource for international collaboration and feedback. It is also worth a bit of investigation to see if there are any online resources that you can benefit from; for example, the British Society for Developmental Biology website has a detailed advocacy section that gives many useful examples and resources in this area [16].

- *Have you spoken to your institute?* A valuable first point-of-contact when developing any science communication initiative is the public engagement/widening participation/schools outreach team at your institute. The title and role of the team will differ on an institute-by-institute basis, but they are a vital resource for sounding out your ideas and sourcing volunteers, as well as for seeing if there are any existing networks that you can take advantage of, and even if there are internal/external funding sources to help support your ideas.

- *Have you tested your initiative?* In the development of your science communication initiatives it also helps to beta-test any planned events or activities. This approach ensures you iron out any technical hiccups (e.g. compatibility of any images or videos with the video equipment to be used); it also helps any participating scientists to feel more at ease, and to be prepared for when the event goes live. Asking postgraduate and undergraduate students to help in this beta-testing phase is normally an effective method.

By taking these points into consideration, you will be more likely to develop effective science communication initiatives. It is also important to remember that the development of these initiatives does not stop after the first delivery, and that it is necessary to iterate and improve your activities, depending on the feedback that you receive [17].

## 2.2 Event logistics

To make sure that an event runs smoothly you need to consider aspects that go beyond mere content. Listed below are several key points that should be considered for the delivery of any science communication initiative:

- *Have you got a detailed plan?* This should include a list of all the equipment you need, a map of where the power supplies are (if required), and a list of volunteers and their contact information. Have you got enough print outs of

everything that you need, e.g. evaluation forms, activity sheets etc.? Do you have spare batteries, paper, enough pens? If not then go and borrow them from the marketing department of your institute should be able to help.

- *Have you sorted transport?* Have you arranged for the appropriate transport of people and all required equipment (which may include tables and chairs) to and from the venue, and decided who will be responsible for setting everything up and taking it down?

- *Have you got a signed risk assessment?* Remember to always keep a copy (it can be digital) with you at the event. Try and send the signed risk assessments to a representative at the venue (e.g. a teacher at a school or an estates manager at a university) at least two weeks before the planned event, allowing you time to make changes that may be requested. In terms of organising a risk assessment, the health and safety staff at your institute will be able to help, and the UK Health and Safety Executive also provides some further guidance and examples [18].

- *What are the location specifics?* If you are delivering an activity off-site from your institute then ask a member of staff from the venue to give a health & safety (e.g. fire escapes etc.) plus housekeeping (e.g. toilet locations etc.) briefing to your entire team; this will save you from having to report back second-hand, and should also safeguard you from missing any vital information. If you are running any activities that involve smoke and/or fire, have all the fire alarms been turned off in advance and with permission? Are you aware of evacuation plans, and have all presenters been instructed, or is there adequate support staff on-site to cover for these measures? Does everybody know whom to contact in the event of an emergency? I would strongly recommend having a briefing session prior to the event to go over all of these points.

- *Do staff at the location know what you are doing?* Are the relevant authorities of the venue informed, such as school or museum management, estates or security? Do they know what times you will be running the event for? Have they made provisions for out-of-hour access if necessary? Will you be able to access the building by car for loading, unloading, and parking during the event?

- *Is everything well sign-posted?* If the event is in a non-obvious location will people know how to find it, and do people know where to park? Was information given in your invitation letters or adverts when marketing the event? Remember to also brief the speakers and other volunteers that you are working with.

- *Is the activity accessible?* Have you made provisions for wheelchairs and anyone who may be visually impaired, deaf, or hard of hearing? A useful resource in terms of guidelines for accessible meetings and events is provided by special organisations, such as the Manchester Disabled People's Access Group [19]; alternatively ask your local museum, as they tend to be well aware of the required measures.

- *Is there catering?* If the event involves catering of any sort (e.g. drinks reception, tea and coffee, etc.), is it clear where this will all be set up? Have you got enough for everybody, and can you enquire beforehand about

special dietary needs or cater for them by default? Have you provided catering for the people helping to deliver the event? At the very least they should be provided with water.

- *Is there someone present who is trained in First Aid?* For larger events, it might be worthwhile asking local services to send a trained first-aider and/or paramedic, which may involve extra costs.

- *Have legal requirements been met?* For example, in the UK a Disclosure and Barring Service (DBS) check [20] is often a prerequisite for working with children, and can take several weeks to arrange. You should always make sure that you are NEVER left alone in a room with a child or group of children; insist that a teacher is present always. Not only can they help in terms of classroom management, but having them there also safeguards against any possible claims of misconduct. Some locations will also require a copy of your institute's public liability insurance certificate, which can usually be obtained from the legal team.

- *How will you document the event?* This is essential for future dissemination. Have you arranged for someone to photograph and/or video the event and do you have the permission to take photographs and videos of the participants? Many schools have strict filming policies that you will need to find out about in advance, whereas for other events it is normally best to have an oral or written announcement that the event will be filmed/photographed, and for people to make themselves known if they do not want to appear on camera.

- *Is all the IT and AV equipment in place and working?* Speaking from bitter experience, if you are running an event that involves presentations on a computer, try to insist that all the speakers get the slides to you well in advance so that you can ensure they run smoothly. It is worth familiarising yourself intimately with the IT setup prior to the event (or even having an AV expert on hand), as invariably someone will want to make a last-minute change or else there will be a software update that needs installing. At some venues, for example in schools, it is often difficult to familiarise yourself with the AV equipment beforehand, and so make sure that you are prepared to be fully self-sufficient, e.g. take your own loudspeakers if you want to show any video with sound, and make sure that you always have a variety of connecting cables and adapters (HDMI, VGA etc.). If working in a school or place of public office, there is also a strong likelihood that any webpage that you have prepared (e.g. a video clip) might not be accessible because of a firewall. Embarrassment can be avoided by checking with a point of contact in advance of your visit, and if necessary sending them the relevant links. The safest solution for videos is to download them using free online-programs and show them off-line.

- *Have you got volunteers?* Make sure that you have arranged for the correct number of volunteers well in advance of the event(s). I would recommend planning for slightly more than needed, based on projected audience figures, and then be willing to let volunteers go home early or take longer breaks. For example, at a science fair, allowing people time to present in shifts so they can walk around and enjoy the event themselves will make it more enjoyable

for them and will enhance the information available on de-briefing sessions. For larger events, you will also need to consider the different roles of the volunteers, e.g. greeters, demonstrators, evaluators.

- *Is there a single point of contact?* For larger events, it is wise to appoint a central coordinator who is reachable by mobile phone or walkie-talkie during the event and can be tasked with making last-minute arrangements, helping with technical faults, or replacing/replenishing materials that have run out.
- *Can you re-use your materials?* The purchase and creation of materials for different events can be extremely costly and/or time consuming, so make sure that you give yourself the opportunity to use them again. This need not always be physical objects or materials; for example, PowerPoint slides can easily be re-purposed for future presentations.
- *Have you planned for the unexpected.* What happens if 50% or 150% of the intended audience shows up? If part of your activity is outside, what happens if it rains or if there is a heat wave? What do you do if a speaker doesn't turn up? For example, if the speaker is central to the event, do you have substitute speakers or prepared substitute talks yourself, so that audiences who have made the effort to come are not put off attending future events?

This is quite a substantial list, but it is by no means exhaustive. It can be used to either write out a checklist or prepare an excel spreadsheet in advance, which you can then tick off as you work your way through all the actionable items, to ensure that you have not forgotten anything. An example of a logistics document for science fairs or school visits can also be downloaded from the droso4schools website [21].

You should also consider a de-briefing session either at the end of the event (although people may be tired) so that you can get an instant response to how people thought the event went, as well as thank everyone for their help. Consider arranging a longer de-briefing session as soon as possible within the following week, to learn what went well, what problems arose, brainstorm solutions or collate ideas for future events. Taking notes and inserting them in any planning documents will be invaluable when you repeat similar events in future.

**2.3 Advertising and promotion**

One of the biggest worries with any science communication initiative is that it won't have an audience. Months of developing, beta-testing and fine tuning can easily become undermined if too few turn up to appreciate your hard work. There are no definite ways to guarantee the audience that you wish for, but there are several steps that you can take to help to maximise your chances:

- *Tap into existing communities.* For example, if you are running an activity about the importance of top-soil to the ecological system, is there a local garden centre or community gardening group whose clientele you could appeal to? Similarly, are there any upcoming events or celebrations that you could piggy-back onto? For example, if you are doing an event related to healthy eating could it be run on or in the build-up to World Health Day? By

tapping into these already existing networks you will be able to build on their marketing initiatives to boost your own.

- *Use mailing lists and social media.* Emailing everyone on your contact list with generic spam is not very effective, and might not be well received. However, sending out a limited number of personal emails to groups of people that you know will be interested in your event can be highly effective. Encouraging everyone that is involved with your event to Tweet about it will also help to spread the word. Consider creating a Facebook group or a website for the event (with a link to any dedicated ticket site – see below) and sharing this via the various social media communities which seem relevant. LinkedIn groups can also be an effective place to share events.

- *Don't forget word of mouth!* One powerful advertising tool at your disposal is other people. If you can create a buzz for your event then this can help to grow an audience, especially all those additional people that you can reach vicariously through social media.

- *Use flyers and posters responsibly.* Flyers and posters are still a very useful way of letting people know about an upcoming event. However, use them smartly. Don't print off more than you need and think about where you place them or hand them out. For example, always have a couple of posters up in the venue of your event in the weeks before it takes place, and consider the strategic placement of them in lifts and toilets, where people will have the time to read them. Another effective method is to find a nearby event that has a similar audience to the one that you are aiming for and hand out flyers during the event and/or at the exit when people leave. Flyers need to be handed out to be effective and are rarely read when placed on a chair or in a bag of materials.

- *Try and drum up some media interest.* This might seem like a difficult task to accomplish, but local media are normally very helpful if you have an innovative event that appeals to a wide audience and has a local angle that they can use. Similarly, most local newspapers will have free weekend listings (either in press or online) that you can get your event placed in. Other local event publications should be considered (in the UK such publications include: Time Out [22], The List [23] and The Skinny [24]), as should local and regional radio stations, many of whom are very happy to talk to scientists about a local event, presenting you with the opportunity to reach out to several thousand (or more) people in the region.

- *Ask your university or institute to help*. At times this can seem harder than getting national press coverage! However, if you manage to get hold of a tame press officer then they can help to promote your event to a large local audience, via their various social media channels and other media outlets, such as community newsletters.

- *Consider ticket sales*. Selling tickets is another way to spread news about your event and it comes with the additional benefit that you will have a greater semblance of control. From personal experience, I have found that for free events about 30%-60% of the people who have signed up bother to attend, but that this increases to 80-95% if you charge a small fee. If this is against the ethos of your event, then provide some catering or small gift in return.

Charging does not only act as a deterrent to people who simply sign up to several events on a whim, but it also adds a perceived value to the event that can help it to stand out in a crowded market.

- *If your event requires ticket-sales, make use of ticketing services*. If your initiatives are part of some larger festival or event then there may well be a local ticket sales office, but most of the time you will be expected to maintain ticket sales and guest lists by yourself. Web-based ticketing services can remove a lot of the hassle from this process. From my own experiences, I would recommend the international web-based ticketing service *Eventbrite* [25]. For free events this comes at no cost, otherwise there is a small handling fee, taking as a percentage of each ticket sale. These online ticketing services usually help to advertise your event through a hosting webpage as well as emailing reminders to attendees. They can also help you manage visitors through an attendee list that can be printed out or even digitally scanned, and offer many other tools that facilitate the management of greater visitor numbers.

As a final thought, if only a handful of people turn up to your event then don't worry, just concentrate on giving these attendees a wonderful experience. I have run events where just one person has turned up, and "we all" had a marvellous time.

## 2.4 Branding and Legacy
Developing a 'brand' can help to make an initiative appear more professional, and can also help to streamline future activities. The following points outline some suggestions for developing a brand and establishing a legacy for your science communication initiatives:

- *Consider your personal brand:* as well as developing an online platform for your science communication initiative, it is also essential to develop your own digital portfolio as an independent researcher. Other articles in this special issue talk about the use of blogs and social media, but given the prevalence that the Internet plays in modern living, having an established and effective digital identity is swiftly becoming an essential part of being a twenty-first-century scientist, not only in terms of effective science communication, but in terms of effective science.
- *Create a logo:* this is an effective way of ensuring consistency amongst all marketing and advertising material. This logo then represents an easily recognisable way for audiences to identify your initiative, which can also be used for digital branding (see below). If you have design experience then generating a logo can be a relatively straight-forward (and enjoyable) procedure. If not, then I would recommend getting in contact with a colleague or friend who does, or else taking the time to develop these skills (e.g. through an online course) – this is time well spent as it can save you lots of time (and money) in the long run.
- *Make a film:* as well as having someone take pictures and document your initiative (see Section 2.2), it is worth making a 2-3-minute promotional video

that explains the essence of your initiative and that can be used for advertisement purposes, or a film that summarises a specific event you organised to document the successes of the initiative and to generate interest for future ones. Producing videos does not need to be expensive or require professional support, as is explained elsewhere in this special issue .[26]

- *Report your successes:* remember to shout about your event after it has occurred. Let your institute know about what you have done, and post out some suitable photos and images via social media to allow those who were there to re-live the event and let others know what they have missed out on, so that they can be there for your next set of activities.
- *Embrace the digital world: s*cience communication initiatives can go beyond face-to-face interaction with audiences. Recent research has shown that these are not necessarily the arenas in which people go to receive their science education [17]; despite merits in events such as science festivals, limitations including geography, time and topic of interest can be a barrier to engagement for some, who might prefer to use the Internet and other digital media to engage with scientific topics. As such it is important to consider the use of online tools to supplement any face-to-face science communication initiatives that you may be engaged with, as well as to consider the use of dedicated blogs, podcasts and other digital methods of communication. Developing an event for delivery in schools to 50 school children is great, but what if those materials were also made available online so that 50,000 school children from across the world could be reached, at any time and from any location [17, 27]?

Considering the branding and long-term legacy of your science communication initiatives is an important step that needs to be considered, and which can ultimately help to raise the profile of your work, in addition to saving you valuable time and money.


## 2.5 Evaluation

A thorough evaluation of your science communication initiatives is essential to enable you to more easily identify whether your long-term objectives are being met. Effective evaluation can help to make the iteration of science communication initiatives more efficient, and can also highlight areas that need further strengthening. Importantly, you may be asked by your funders or home institution for data that demonstrate impact of your activity. For example, in the UK, universities are required to prepare impact case studies for the Research Excellence Framework [28].

However, science communication evaluation is often restricted to very basic strategies, such as recording how many people attended the event, and possibly whether they enjoyed it or not. Whilst this is useful information, it is not particularly helpful in determining if the objectives of your initiative have been reached, making

it more difficult to build an impact case study around such an initiative. In my view, there are three types of evaluation:

1. *Metrics.* These are the most basic pieces of data regarding your audience. How many people attended your event? What is the age range of the attendees? What is the gender split? Think carefully about the type of demographic information that is useful to you and try to avoid any questions that could be interpreted as unnecessary or inconsiderate. This data can be collected either face-to-face or digitally (see below).

2. *Event evaluation.* A typical strategy to evaluate events is to ask the audience using short audio/video interviews or questionnaires. How much did they enjoy the event? Was it pitched at the right level? Where did they find out about the event? Was there anything that could be improved? The responses from these types of questions will help you to develop both further iterations of the event as well as other future activities. Remember also to ask the participating scientists and volunteers who have helped to deliver the event what they have made of the process. Could you have improved your communication with them? Was everyone aware of the objectives of the event? Did people learn any skills or make experiences that will change their attitude and performance on future events? The various forms of feedback you receive from evaluations can also be used for testimonials and to promote future events.

3. *Objective evaluation.* These are the questions that will help you to establish if your event has succeeded in achieving the objective of your science communication initiative. This evaluation relates to the 'why' aspect of your event or activity. Try and apply the scientific method to this approach, i.e. define a hypothesis, test this hypothesis and then re-evaluate this hypothesis. For example, if you are organising a series of events to raise awareness of antimicrobial resistance amongst school children, then your hypothesis might be that your initiatives will act as an intervention to raise awareness. To test if this has been achieved or not you would first need to establish a baseline in terms of the children's knowledge prior to your intervention, and would then need to revisit this immediately following your event(s) and then later as well (maybe 3-6 months in the future). This long-term and systematic approach is the only way that you can determine quantifiably whether your objectives have been met, which is perhaps the most important piece of information you would want to gain.

When you are designing your evaluation, it is important to think about the type of questions that will be useful for further developing your initiatives and testing your long-term objectives as well as the delivery mechanism via which the evaluation will be conducted. Online evaluation tools (such as Google Forms [29]) can make later data analysis easier, and can also be sent out to mailing lists of attendees both prior to and after an event; however, there is no guarantee that anyone will respond. Likewise, if you are encouraging participants to fill in an evaluation form directly after the event is there a way in which to do this so that it is at least semi-interesting and doesn't require an additional 10-15 minutes of a person's time? Nothing can

undo an audience's goodwill faster than if they are forced to take part in a tiresome evaluation activity. For example, could you ask the participants to draw a picture of how the activity made them feel, or ask them to write a poem about what they thought they had learnt?

Further details about developing an effective evaluation strategy are contained elsewhere in this special issue [Reference to be inserted], and there are also several useful online resources, including from the NCCPE [11] and UCL [30]. By successfully evaluating both your event and your long-term objectives you will be able to analyse your own practice in a measured and integral manner, whilst also contributing to the literature in the field by writing up your findings as a case study to be considered for publication. Whilst this may seem daunting, it is an excellent way in which you can demonstrate to others the value of what you are doing, and can also serve as an excellent formalisation of impact, e.g. for the Research Excellence Framework. Collaborating with other social scientists and professional science communicators can also help to ease this burden significantly.

## 3. Final Thoughts

Delivering effective science communication can be a time-consuming and resource-draining task, especially if you are having to teach yourself a whole new skill set on top of your other academic commitments. However, it is also an extremely rewarding and enjoyable pursuit, which can help to further develop skills that are useful in other areas of academia, such as communication and networking [31].

The advice that I have offered above is based on my own experiences. However, the best piece of advice that I can offer for developing and delivering effective science communication initiatives is to consider working with other professional science communicators and social scientists. The pressures that are placed on scientists in terms of research proposals, publication preparation, teaching commitments and other administrative duties means that it is simply unreasonable to expect them to also excel at innovative and effective science communication. Professional science communicators and social scientists will be able to help with all the above; easing the burden associated with logistics, assisting in the setting of clear, long-term objectives, and helping to effectively evaluate the process. A good place to find these experts would be via the public engagement team in your institute. If you do not have such local expertise, then a good place to start (in the UK) would be the BIG STEM Communicators Network [32], a skills-sharing network for science communicators, where you can advertise for the expertise that you require on their mailing list. These people are all experts in their field, and as such they will be aware of any new research and best practice in the field of science communication, allowing you to better focus on developing the long-term objectives that should underpin any successful science communication initiative.

## Abbreviations

DBS - Disclosure and Barring Service
NCCPE – National Coordinating Centre for Public Engagement
PUS - Public Understanding of Science
PEST - Public Engagement with Science and Technology

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