JOURNAL OF MICROBIOLOGY & BIOLOGY EDUCATION
DOI: https://doi.org/10.1128/jmbe.v19i1.1532

Learning from History to Increase Positive Public Reception and Social Value Alignment of Evidence-Based Science Communication

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For effective science communication, three general objectives should be taken into consideration: 1) accurate conveyance of the scientific evidence; 2) warm public reception of the communicator; and 3) alignment of the information with social values. An examination of both successful and failed science communication efforts over the course of history can reveal strategies to better meet these objectives. This article looks back at influential moments of science communication over the past two millennia in the context of the objectives and, using lessons learned from these events as a guide, introduces a five-element approach to improve the potential for attaining the objectives.

INTRODUCTION

The past few decades of science communication research (1–5) have revealed three common objectives to improve effectiveness:

1. Information must be accurate and based on evidence
2. Communicators must be received warmly by the audience
3. The information must align with current social values.

Achieving the first goal should be straightforward for most science communicators as it utilizes a one-directional approach common to dissemination of knowledge in the academic realm. The other two present a greater challenge, as they require a relationship between the communicator and the public (4). This necessity for two-way dialogue can leave those unfamiliar with public interaction at a significant disadvantage and prone to issues such as bias (6).

Science communication is a relatively young branch of research (7), yet the activity of sharing science with the public spans back millennia. Looking at the stories of the past offers not only a recollection of these activities but also a list of advantages and pitfalls associated with various science communication approaches. This information can be distilled in order to synthesize new paths forward.

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Received: 17 November 2017, Accepted: 6 December 2017, Published: 30 March 2018.
†Supplemental materials available at http://asmscience.org/jmbe

This article serves to explore pertinent moments in science communication history and use them as a guide to support a new strategy for achieving the three objectives. Known as the 5Es, this approach incorporates five elements: education, enrichment, engagement, entertainment, and empathy. Each element first will be explained based on its historical context; suggestions will then be made on how to apply each one to improve the chances of meeting the three objectives of accuracy, reception, and alignment with values.

LOOKING BACK IN TIME

The ancient approach

In the first century BCE, the Greek philosopher Lucretius composed a 300-page poem, *De rerum natura*, which translates as "On The Nature of Things" (8). The work revealed the mysteries of the universe through poetic phrasing. Yet beneath the flowery language and tone was an exploration of the principles of Epicurean physics, upon which our current Laws of Thermodynamics (9) were founded.

Lucretius's words spoke to the public, but the science as academics knew it then remained accurate. His approach was warmly received by the public, as art was a favored pastime. But his words did not align with Caesar, who favored personal ambitions such as hedonism and power. Yet, the people were tired of their political leader (10) and were looking to learn more about the world around them. Lucretius was at the right place at the right time.

A separation from values

For centuries, conveying evidence in tune with social values was effective, as science was mainly theoretical and philosophical in nature. As centuries went by, systematic methods were utilized to test the natural world and evidence became more detailed. Communicators needed to focus on accuracy over reception and values. This inevitably led to a rift between science and the Church, in 1514, when Copernicus discovered the Earth was not the center of the universe.

Based on his celestial observations, Copernicus concluded the Earth revolved around the sun, not the other way around. He published his findings in the book, *De revolutionibus Orbium Cœlestium* (On the Revolutions of the Heavenly Spheres) in 1543 (11) to awaken the public to the new reality. Unfortunately, the results conflicted with the beliefs of society's greatest influence at the time, the Catholic Church. The book eventually was banned, and any attempt to revive Copernicus' work was met harshly. This was epitomized with the 1633 trial and conviction of Galileo Galilei (12).

The action of the Church had a significant impact on the scientific community. Science communication in the public realm was no longer beneficial to scientists, and they abandoned the effort (13). Researchers shared evidence without a care for translation. Discussions of scientific research were relegated to the pages of academic journals, compendia, and textbooks. As for the public, they rarely had the chance to gain any appreciable knowledge of the advances occurring in the scientific realm.

Focusing on reception

There were notable exceptions to the practice of hiding science from the public. The most famous was Charles Darwin. In 1836, after his aquatic tour of the world aboard the *HMS Beagle*, he shared his findings of biology, including specimens collected from around the world. His publications, collectively known as *Journal of Researches,* were hailed by the public and in the media. However, this excitement was not due to a change in social values. Instead, the accolades focused on Darwin's exploration of worlds few would ever see. Darwin became a celebrity for his artistic endeavors, not his science (14).

Despite his fame, Darwin wanted acceptance as a scholar. He had the chance 13 years after the publication of his voyages, with the release of his most famous work, *On the Origin of Species By Means Of Natural Selection* (15). Unfortunately, his theories of evolution did not align with the longstanding religious belief of creationism. His arguments were dismissed by the Church, he became the target of ridicule in the press, and he lost his esteemed position in the public eye (16, 17). Even today, Darwin remains one of the most controversial figures in science and his theories still are the focus of much debate (18).

The need for accuracy

During the 1800s, with the scientific community for the most part secluded from the general public, science became a marketing tool. Individuals with at best minimal amounts of scientific training sold products that would, in their expert opinion, improve quality of life (19). These individuals, now commonly called snake oil salespeople, used inaccurate representations of scientific evidence to prove their products would benefit health. Without the presence of scientists to challenge these views, many in the public believed the claims, and profits rose. In most cases however, the assertions were never realized (20).

For one particular microbiologist, Ludwik Fleck, this new reality was problematic, as the rise of inaccuracy threatened trust in science. To counter this trend, he wrote a 1935 monograph entitled, *Entstehung und Entwicklung einer Wissenschaftlichen Tatsache* (Genesis and Development of a Scientific Fact) (21). Using microbiological and immunological examples, Fleck revealed how scientific evidence may be absolute in appearance but could be interpreted in a variety of ways.

This variance of interpretation, which he called a "thought style," meant data could be misinterpreted by those who did not understand the mechanism behind the evidence. Unless information was conveyed by specialized experts in the field, factors such as bias, social perspective, and morality could lead to an altered message and incorrect conclusions. The only way to avoid this was to ensure an accurate portrayal of evidence was achieved. The public would have no choice but to accept the information because it was true. The approach was, however, one-dimensional and, not surprisingly, unsuccessful in the general community. Yet his recommendations pioneered the development of public science education (22) in which evidence is shared as fact rather than merely as interpretation.

Seeing is believing

The concept of two-way interaction evolved thanks to the advent of television. In 1951, Don Herbert introduced us to Mr. Wizard (23), who performed science experiments with children and invited viewers at home to recreate these activities. Within five years, children all over America joined "Mr. Wizard Science Clubs," and learned science as participants. This approach became so popular it eventually took on a life of its own and continues to this day in the form of citizen science (24).

In 1959, physicist Julius Sumner Miller (25) had a different approach with his show, "Why Is It So?" He used children's programming to explain physics to a wider audience. Adopting a 'mad scientist' persona, he encouraged the audience to learn more by themselves to keep up with him. The audience followed along without ever knowing the educational level was equivalent to senior high school and undergraduate university. His approach to science education outside the classroom inspired audiences to learn more about the mechanisms behind the observations (26). The addition of "homework" helped to ensure the information stuck with the viewers long after the episode had ended.

In the 1990s, engineer and comedian Bill Nye adapted both approaches to gain success. Much like Miller, he adopted an eccentric stereotypical appearance, complete with lab coat and bow tie (27) and filled his scripts with entertaining phrases that added humor to the evidence. As for his experiments, they were easy to follow and to perform at home, much like Mr. Wizard's. Nye received unprecedented success and was entrenched in popular culture.

Learning from the past

While each of these historical moments is unique, as a collective they reveal five common elements that may help communicators achieve the three objectives of accuracy, warmth of reception, and alignment with values. The adherence to education by Copernicus, Galileo, and Fleck is essential to fulfilling the first objective. Lucretius and Darwin enhanced experiences with art, leading to warm receptions by the public. Herbert and Miller's vision of engagement brought science out of the lab and into the home, improving the alignment with social values. Nye revolutionized how entertainment can increase the reception and the value of evidence sharing. These four elements, education, enrichment, engagement, and entertainment comprise the first four Es of the approach. The fifth, empathy, is based on the need to identify with the audience in order to gain their reception and improve alignment with social values.

THE 5Es

Education

Education is the foundation of any science communication effort. As Fleck points out, the story must start and end with the evidence, and communicators need to ensure accuracy. Most communicators do their best to adhere to this element, yet some may attempt to make evidence easier to understand by leaving out certain details. This practice, colloquially known as dumbing down, has numerous potential drawbacks, such as overstatement of the evidence, oversimplification of mechanisms, and a less than definitive conclusion. The latter may allow some to shift the meaning to fit their own personal values.

When faced with a complex experiment, mechanism, or terminology, an effective approach to explain the information is to discuss its backstory. Scientific evidence usually has a long history, and the communicator can take the audience on a storyteller's journey of discovery. Another approach is through the use of imagery. Figures, videos, props, demonstrations, and gaming technology can provide the audience with an opportunity to see the evidence in a relatable manner. This approach also may increase the chances for a warm reception by the audience.

Enrichment

The goal of enrichment is to ensure the information conveyed to the audience is not only heard, but also plays a role in an individual's life. As Lucretius, Copernicus, and Darwin learned, for this to happen the third objective must be met. Information must align with the values of the social fabric.

Values can be broken down into social issues and personal beliefs such as religious faith (28). Successful enrichment focuses on adding to the former while avoiding conflict with the latter. This is a difficult challenge, as communicators first must determine whether a scientific outcome melds with social values or whether a rift will form due to personal beliefs. This requires an examination of media, both traditional and social, to determine which issues can outweigh personal values. Some include individual health, economic stability, and environmental sustainability. When enrichment is done effectively, the output can be seen as a way forward for society rather than a contravention of dogmatic tenets.

A word of caution must be made here. No matter how effective the enrichment may be, communicators should expect a minority of detractors for whom no amount of enrichment will sway beliefs (5). This is an inevitable drawback to science communication. Values such as religion and political doctrines (29) can be seen as far more powerful than evidence. While these people cannot be ignored, they should not deter science communication efforts.

Engagement

The first two elements are one-directional in nature and serve to fill gaps between academically trained individuals and those who have not acquired the same education. Engagement fulfills the requirement for a two-way connection (2, 4). Although best practices continue to be debated, the various models for developing dialogue have one common goal in mind: they all strive to spark participation from an audience. Engagement has become one of the most important tenets in any science communication effort and, as such, should be considered by any communicator.

The possibilities for engagement are numerous, and all communicators should consider utilizing at least one approach to improve their chances at creating and maintaining the two-way dialogue. As to which ones work best, the communicator must decide based on personal comfort level and professional reach within the public sphere.

For those with large audiences, such as Mr. Wizard, Julius Sumner Miller, and Bill Nye, engagement can come in the form of homework or participation in clubs. In smaller settings, a hands-on approach may offer an excellent opportunity for engagement. Demonstrations of evidence such as those seen in museums and science expositions can increase reception and assist in aligning the science with values. The addition of multimedia, such as gaming technology or the use of virtual reality imagery, also can give added value to the experience.

Engagement is not limited to face-to-face encounters. For example, in a public presentation or live interview on radio, television, or podcast, the communicator can open the lines for "Question and Answer" periods. If information is being shared in a written format, such as a newspaper column, magazine article, or blog, a contact e-mail address should be provided. This enables the formation of a social link between the communicator and the audience and increases the chances the communicator will receive a warm reception.

For many communicators, the easiest and most applicable route for engagement is social media. While this does provide the communicator with a cost-effective approach, there is a significant risk associated with this option. As social media is a true democracy, a communicator should expect to see conflict, belittling, and mockery resulting in an urge to fight back (30). A communicator should be prepared to discern between negative feedback and purposeful attempts to deride an individual, commonly known as trolling. In the latter case, the best option is to ignore the comments, as they are not focused on the objectives but rather are an attempt to invoke personal harm.

Entertainment

Once communicators understand the values held by target audiences, various cultural influencers of that demographic can be used to help develop enrichment and effectively engage the audience. As Nye revealed, the use of entertainment can increase the appetite for knowledge in the audience. Although his approach used humor, other genres also can increase interest, including music, sports, television programming, movies, colloquialisms, and references to popular culture. Communicators can utilize knowledge of their audience demographic to include relevant context to increase the alignment of the evidence with specific social values.

There is no one best means to entertain an audience. A communicator must evaluate individual skill sets and translate them into science communication efforts. For example, Nye's success was founded in his ability not as a scientist, but as a comedy writer and performer (www.biography.com/people/bill-nye-20950589). An honest appraisal of one's own talent can set the stage for an entertaining look at the science, a warm reception, and possibly an alignment with values.

Empathy

Empathy by definition is the ability to understand what it is like to be in someone else's shoes. It is not, however, morality (31). The two are separate entities (32). Morality is an abstract base for social values and usually is based on belief (33), whereas empathy is a neurological entity (34, 35) and can be both involuntary, such as the phenomenon of automatic mimicking (36), or voluntary as a trained skill (37–39).

Using empathy can improve the likelihood of getting a warm response and increase the chance of alignment with values. The level of empathy needed varies depending on the audience. Researchers have indexed levels of empathy in the medical profession (39–43), but no such monitor exists in science communication. The best option to gain the right level of empathy based on the evidence of skills training is to identify and collaborate with nonexperts who represent the target audience. They could be family members, friends, or social media contacts. Share with them in an honest manner and make it clear their thoughts should be shared freely albeit constructively. This facilitates a functional two-way dialogue that can improve empathy in a wider setting. Moreover, this approach allows the communicator the opportunity to test different science communication approaches in a controlled environment.

CONCLUSION

Research has shown the three objectives of accuracy, reception, and alignment with values are the benchmarks for communicators. Thanks to millennia of science communication efforts, we have gained insight into the development of successful approaches as well as the problems associated with failures. This paper has introduced the 5Es approach, which can act as a roadmap, paved by history, to improve the chances of reaching these goals. By taking the time and effort to focus on each element in any science communication strategy, and subsequently developing protocols to fulfill the requirements, communicators may find viable options to improve effectiveness of their efforts and achieve the objectives of accuracy, warm reception, and alignment with values.

ACKNOWLEDGMENTS

The author declares that there are no conflicts of interest.

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