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REVIEW ARTICLE

Effective Ways of Communicating Science to Common People

PRAVEEN B. GAWALI AND RAHUL RAWAT
Indian Institute of Geomagnetism, Navi Mumbai
Email: pravin@iigs.iigm.res.in

ABSTRACT

Due importance is not accorded by scientists to public outreach activities, probably due to their busy research and administrative schedule. However, even if they want to devote their time they cannot do it in a sustained manner because of "(over) specialization". Creative science communication is hindered by alleged 'egoist' feeling that it is an act of "copying" and "over-simplification" making the purists cringe to the core. However, it must be borne in mind that all current science is combinatorial. It derives from a diverse set of disciplines and research that has already been done by generations. It's a networked knowledge that needs to be effectively communicated to the masses by combining the disparate pieces of inspiration, knowledge, skill and talent that are accumulated over the lifetime. These need to be stitched together or recombined into new creations for easy understanding and consumption of the common people. Science communicators need to cross-pollinate to create and evolve new ideas.

Science communication to the common people needs an assortment of techniques that can appeal to the "interested" and "non-interested" participants as well. Both these constituents are an important segment, hence efforts should be made to make science communication a participatory event rather than a unidirectional flow of information. The participatory model should strive at creating an ambience of reflection and rumination, on the ideas that are floating around, so that the information that is being discussed can seep into the psyche of interested as well as un-interested participants. Hence, the effective communication of a scientific idea also rests on the shoulders of the participant, and not just on the communicator. This will induce the communicator to explore new, innovative and effective ways to reach the audience.

The new integrated social media platform can be harnessed since it provides an opportunity to effectively engage with a wide spectrum of common people comprising students, teachers, academicians, aspiring scientists and technologists, not just locally but globally. This approach will encourage wide participation and greater returns on time invested. It will also give quantifiable metrics on their impact.

KEYWORD: Science communication, Outreach programmes, Social media

Introduction

Science and technology has allowed raising the standard of living of people that populate this world. Though the wealth created by harnessing of these twin modes is not equitably distributed, it is, in fact, the only means that has the potential to achieve a uniform spread of progress throughout the world. The relationship between the lay people and science has changed considerably from pre-industrial days to post-industrial ones[1].

The Second World War impacted the entire globe in one form or another. This war was made chillingly more vicious by the advances in the scientific and technological arena. Towards the end of this bloody war, US President Roosevelt was anxious to know what science can do in peacetime. He posed this question to his director of the US Office of Scientific Research and Development, Vannevar Bush. He replied to the President[2], "Advances in science when put to practical use mean more jobs, higher wages, shorter hours, more abundant crops, more leisure for recreation, for study. . . . Advances in science will also bring higher standards of living, will lead to the prevention or cure of diseases, will promote conservation of our limited national resources, and will assure means of defence against aggression".

It must be noted that the war years were dedicated to developing equipment of mass destruction. In later years, however, the shift was towards agriculture. In developing nations like India, the need to concentrate the meagre resources on annihilating poverty and food scarcity assumed inherent importance and the green revolution was a result of that priority. India, in the decades of 60s and 70s, put to use its scientific and technological resources to build an agrarian economy, dedicated to weed out pests and diseases affecting plants and animals, and

in increasing the yield of the crops. But, later, when there was a sense of achievement of the stated objectives the government and the intelligentsia moved on to other forms of research which were less familiar to the masses like the computers, electronics, antibiotics, nuclear and other defense-oriented fields. Science thus became an entity for the laity that was out of bounds for them. To experience it and appreciate the developments in science and technology, the laity feels, is not an absolute necessity. The feeling is on the rise regarding the exclusiveness of science, which is out of bounds for them in terms of application and comprehension.

At the start of the industrial era, science was considered to be the sure and safest route to economic development. The post-industrial era, however, takes science and technological development for granted and it is now viewed with great suspicion. The atomic bombing and the genetically modified food has put a streak of scepticism in the minds of the modern era people. The change in mindset between the pre- and post-industrial age has altered the way science is viewed. The pre-era witnessed people going out of their way to understand science and how it could benefit self, and consequently the society. Great scientific minds like Aristotle and Faraday, along with many others found ways and means to communicate their findings to the general public.

The alleged display of the law of motion, from the leaning tower of Pisa, by Galileo, was meant to impress upon the laity how subtle is the work of nature. He was trying to clean the minds, of the influence of Aristotlean myths and legends, on the then general public. Differently weighing particles travelled at different speeds was the "supposition" pedalled by Aristotle. Galileo wanted to undo this "false" piece of information. Allum *et al.*, suggest people who have a scientific bent of mind have a positive attitude towards science in general. This makes it mandatory to then inform the public about science and technological developments that impact their lives in more ways than one. Science communication, in today's world, is an absolute necessity[3].

The world over science communication has been carried in right earnest. The big scientific names like Carl Sagan, Jayant Narlikar and Stephen Hawking have lent their voice and efforts

to popularise science. They, along with many others, have been incessant in their task to reach out to people. Public Awareness of Science (PUS), Public Understanding of Science (PUS), Scientific Culture (SC) and Scientific Literacy (SL) are some of the terms in vogue in global science literature and are often used interchangeably. Burns *et al.* have defined and brought out the nuances of these terms and why they should not be used as optional terms for one another. According to them, the public is every person in society and participants are members of the public who are directly or indirectly involved in science communication. The relationship between the two and the interaction between them produces some response which is integral to the outcome of science communication[4]. Schirato and Yell reckon science communication takes place under specific social, cultural and political conditions[5].

American Association for the Advancement of Science felt the need to have a close look at science and society and where science communication fits in this scenario. It has felt the relationship between science and the public is at a critical phase and the choices that will be made in the near future, deliberately or inactively, will deeply impact the future of science as well as society[6]. Some of the surveys carried out suggest enhanced levels of interest in matters related to science, but a drop in the measurable understanding of science[7]. While analysing models related to the communication of science, Gross feels the deficit model is a unilateral flow of science to the public[8]. The public is a passive receiver. He favoured the contextual model wherein the flow of science is not merely to people, but people are also able to give it back to science. This is a two-way flow of knowledge and in this communication, the cognitive, ethical and political needs are also taken care of. However, now a new concept of science communication has evolved which combines all the vowels of the English alphabets, AEIOU[4], and depicts awareness of science, enjoyment or other effective responses to science, interest in science, the forming, reforming or confirming of science-related opinions, and understanding of science. The vowel analogy according to Burns *et al.* is the right kind of label that personalises the impersonal aims of scientific awareness, understanding, literacy and culture, and thereby defines the purpose of science communication[4].

Earlier, science communication was thought to be an act of professional communicators like scientists, journalists, information officers and so on or it was just considered to be the promotion of the public understanding of science[9]. There have been many definitions of what and how science communication can be done, and between which entities it can be carried out. However, all these definitions encompass the terms that carry out communication between individuals/policy influencers and entities that have something to do with science like the scientists and journalists. The cultural aspect is missing in most of these definitions. The most apt definition of science communication is seen to come from Bryant, who considers it as the process by which the culture and knowledge of science are absorbed into the culture of the wider community[10].

How do People Absorb Scientific Thought?

The understanding of this question is an important step in communicating science to the common people. In India, the basic form of science is absorbed by the people through their school and college curriculum, in what can be described as "textbook" knowledge about science. This is the primary step in imparting science "education". The teaching of science is a universal concept and the results indicate it to be an effective step. The curiosity to know more about the natural processes and the applied aspects of science in the form of technology is well appreciated.

However, the increasing levels of education are seen to split the students down the line into many streams that flow into the domains of commerce and arts. This bifurcation of interest is responsible for alienating a large section of the literate population. Added to that are low levels of literacy in a large spatial extent of the country which is deleterious to scientific literacy. Scientific illiteracy is also pervasive in developed nations and has been brought out in strong empirical confirmations. Allum *et al.,* have surmised a weak correlation between knowledge about scientific facts and processes hampering positive attitudes to science. This is a very important facet of effective science communication[3].

It is felt the public perception is absolutely essential for dissemination and appreciation of elements inherent to scientific

thinking. If the population is not pinned down by ignorance and scepticism of science and technological innovations, then they would be in a better position to appreciate what it means to harness the power of nuclear energy or genetically modified crops. With the shortfall in energy and food demands, the knowledge of these two vital developments can go a long way in effective implementation and gains of the technology. Most of the surveys carried out in the western world have found positive as well as negative correlations favouring a range of scientific fields[11], like embryo research, biotechnology, agricultural biotechnology, GM food and so on.

Durant *et al.,* from their research in Britain and the USA concluded the general public does not know much about science. They are quite interested in science but possess low levels of knowledge about science. They found 66% British and 62% American respondents understood what probability means, only 34% British and 46% Americans knew the Earth rotated around the Sun once a year. Only 28% and 25% Britons and Americans respectively knew antibiotics are not effective against viruses.

Over the years the attitudes of the people of these two countries may have seen improvement. Durant *et al.,* have looked at how far the Britons are interested in themes related to science and technology. They found the highest level of interest in new medical discoveries, followed by new inventions and new technologies, sports, films and politics. The same pattern was found in America. However, the level of understanding about the scientific and technological inventions was found to be very low amongst them. They found some discrepancy in interest and understanding[12]. Some of the questions they designed to measure scientific understanding are quite interesting and given in the following Table:

QUESTION	TRUE (%)	FALSE (%)	DON'T KNOW (%)
The centre of the earth is very hot	80.3	3.8	8.3
All insects have eight legs	7.9	83.7	8.3
The oxygen we breathe comes from plants	59.9	28.3	11.8
Radioactive milk can be made safe by boiling it	12.9	65.1	22.0

Lasers work by focusing sound waves	20.1	41.8	38
Sunlight can cause skin cancer	93.5	3.2	3.2
Hot air rises	96.7	1.2	2.0
The liver makes urine	25.4	53.1	21.4
Electrons are smaller than atoms	30.9	23.5	45.3
The continents are moving slowly about on the surface of the earth	71.7	8.1	20.1
The future children of a bodybuilder will inherit the benefits of his training	12.7	76.7	10.7
Diamonds are made of carbon	58.9	15.5	25.3
It is the father's gene which decides whether the baby is a boy or a girl	51.2	26.1	22.5
Antibiotics kill viruses as well as bacteria	54.5	28.6	16.7
Natural vitamins are better for you than laboratory-made ones	69.6	17.7	12.6
Common table salt is made of calcium carbonate	36.5	31.1	32.3
The earliest humans lived at the same time as the dinosaurs	31.6	46.2	22.1

There are some more questions in Table 3 of Durant *et al.* that reveal the pattern of Britons' understanding of science in which they found young knew more than old, male knew more than female, and middle class knew more than working class[12]. They also found the strongest association between education and scientific understanding. Thus, science literacy has wide implications in the decision-making process and will not augur well for any healthy debate when there is a lack of understanding about basic scientific concepts. Hence, it augurs well if the science communication process is expedited to raise the scientific awareness of the common people.

Relationship Between the Scientists and Public

Scientists are the practitioners of science in that they are involved in the advancement of science through theoretical or experimental constructs. Science is one of the tallest achievements of any culture that has helped humans to create a genuinely healthy and wealthy lifestyle giving it ample time to think and ruminate over issues that need attention. This could be in the health sector or the energy domain. The prioritisation of

issues is commonly dictated by the needs arising gradually or abruptly.

The Indian government has its priorities set in many sectors aimed at creating ease of business at various cultural and socio-political levels. However, the advent of an earthquake in an allegedly seismically stable region like Maharashtra or the tsunami that hit its southern shores forced many of the science institutes to probe these phenomena through different chemical and geophysical modes. In such "emergency" cases there is some sort of tacit understanding of the public to allow the focus and spending of meagre resources on these studies. However, in many other "routine" exercises of the investigation, the general public is quite disinterested to know of its impact. In view of this, we need to understand the relationship of scientists with the general public.

Survey after survey, it has been found that scientists are not too confident about what the public knows of science[13]. They also have a strong feeling that apart from a minuscule population the public is not interested in raising their awareness of science[14]. They also consider the public to be not rational and lack in systematic thinking relying too much on anecdotes[15], unable to change conceptions in view of new evidence[16], overtly attracted to sensational[17], too sensitive to minor risks [18]. Because of these and many other "shortcomings", the scientists are of the opinion that any dissemination of information to the laity should be visually appealing and entertaining[19].

The MORI/Wellcome Trust survey of scientists found 53% scientists felt public lacked in education because of which it cannot appreciate science; 26% felt they did not understand the processes of science; 35% felt the media was the problem, is not able to convey science to the public; whereas 22% said there was a lack of interest to understand science in the public[20]. When the scientists were asked to list their own shortcomings, about a third of the surveyed scientists acceded that the scientists were to blame; 20% felt scientists lack communication skills, and 11% agreed to scientists havinh limited interest in science communication.

However, the recent data from AAAS/Pew suggests scientists do not consider the lack of scientific knowledge on part

of the public as too much of a problem[13]. They also found practitioners who are young, in engineering, physics and math viewed their research to be too specialised, and those in medicine and environmental sciences considered their research to be accessible to public comprehension. Studies have shown 44% scientists think public sees scientists are uncommunicative, 44% thought scientists to be secretive, and 6% thought scientists were detached[20].

Scientists and Outreach Activity

The scientific workforce in India, as the one around the world, is involved in solving, resolving a range of issues with the help of knowledge they possess with respect to comprehending the natural processes that intrigue them. Gone are the days when the research was carried out for the "love of science". The basic research is fast becoming a thing of the past. Einstein's theory of relativity and the famous $E=MC^2$ was just an academic exercise, which later revealed its applications in many spheres of life. Today there may not be a branch of science that does not apply the knowledge of relativity. The emphasis these days is to go after the applications. The need to harness science and technology to solve many of the problems hampering the wellbeing of society is the need of the hour.

We cannot ignore this vital necessity. Because of the changed focus of the different governments to adequately feed its people and look after their wellbeing, in the face of rising population and increased danger of natural disasters to the very existence of life forms, the scientific taskforce does not have an option to satisfy their primal urge of "understanding nature" just as a standalone theme. They have to apply some angle of "societal benefit" to their research. This is putting undue pressure on them.

One more parameter has been added to the activity that they have to carry out. In addition to the scientific work, it is now increasingly becoming incumbent among them to take their findings to the common people, in addition to the policymakers. However, the scientists feel they are being burdened with this "extra" activity which does not benefit them in their actual research activity or in their career progression. Hence, they are

reluctant to spend time on science outreach. In any case, there are some who want to take their principal research findings to the people that do not form a part of their own research problem. They want the non-specialists to know about the kind of research they are carrying out and how it has some potential benefits to the society and their country. This they try to do, in India, through the "Science Day – February 28" activities, to commemorate the discovery of "Raman Effect". On this day, most of the research institutes open their gates to the laity, especially the school and college students. Exhibitions and talks or science-themed documentaries are screened in a bid to inculcate scientific temper amongst the visitors. This activity is looked forward to by many scientists since it gives them an opportunity to interact with total strangers who display some interest to understand how science is 'done' in some of the prestigious institutions. But, this is not a sustained activity. The other occasions are the Indian Science Congress and India International Science Festival held every year in different parts of the country. Some more exhibitions are also held, but not all are patronised by the Indian institutes.

One of the factors that seem to hamper popularisation of science is the compartmentalisation of science streams. The more the scientists work on a particular theme or topic, the more they become involved with it, ignoring the strands of progress in other related research areas. This over-specialisation is not conducive to effective communication. At the same time, there is a lack of originality in something that the scientist wants to convey because he or she is not dealing with their 'own' work. A feeling of copying somebody else's work creeps into their mind. Also, the attempt to simplify certain concepts or the processes to the liking of the non-specialists make the scientists cringe with dismay. It is now dawning upon many of them that all current science is combinatorial. It derives from a diverse set of disciplines and research that has already been done by generations. It's a networked knowledge that needs to be effectively communicated to the masses by combining the disparate pieces of inspiration, knowledge, skill and talent that are accumulated over the lifetime. These need to be stitched together or recombined into new creations for easy understanding and consumption of the common people.

Scientists are now trying to cross-pollinate different shades of knowledge to create and evolve new ideas.

In an Argentine survey[21] researchers revealed they wanted to carry out popularisation of science due to a sense of duty, bringing in awareness of discipline, transmitting the importance of science, fighting the irrationality of the public, the justification for funding, attracting students to discipline and so on.

The ones who did not participate in science popularisation announced they did not do it because it takes time away from their research, lack of institutional support and their research was too technical and difficult to be understood by laity even if simplified. The science communicator has to collect information, synthesise it with insight to germinate plausible ideas that are palatable to the laity. In that sense, this combinatorial creativity implicitly agrees it is not original. This sense of not building from scratch, or by your 'own' mind, creates a feeling of not being worth the effort and time to propagate science to the non-scientific minds.

How to Improve Science Communication?

The human mind is innately curious, and it is this quality that essentially defines humankind. But, the curiosity which is rudderless and directionless, can be incoherent and an unproductive endeavour. The "intention" and "attention" need to go hand in hand. The giver and taker of knowledge, both, need to allocate time, energy and talent to effectively understand each other. Science outreach initiatives can be a successful venture if this harmony is seamlessly achieved.

Science communication to the common people needs an assortment of techniques that can appeal to the "interested" and "non-interested" participants as well. Both these constituents are an important segment, hence efforts should be made to make science communication a participatory event rather than a unidirectional flow of information. The participatory model should strive at creating an ambience of reflection and rumination, on the ideas that are floating around, so that the information that is being discussed can seep into the psyche of interested as well as un-interested participants. Hence, the effective communication of a scientific idea also rests on the

shoulders of the participant, and not just on the communicator. This will induce the communicator to explore new, innovative and effective ways to reach the audience.

One of the benefits of science communication to scientists, apart from the tangible and intangible benefit to the public, is an improved communication of basic scientific research[22]. The Austin students and researchers from the University of Texas have initiated two outreach programmes aimed at school children, (a) Present your PhD thesis to a 12-year-old, and (b) Shadow a scientist (http://cns.utexas.edu/fri). The participation of scientists in these programmes has seen enhanced levels of their commitment to outreach and also enhanced levels of understanding of science by the participants[23].

How can One Reach a Wider Audience?

The characteristic feature of all the science communicators, with a few honourable exceptions, in India, is that they are all researchers and involved in one or many science projects of their own organisation or of some other extraneous institution. They seem to take science popularisation very seriously and are actively involved in communicating their research and its findings to the non-specialists. Journalists, who are not scientists, rely on information shelled out by the practitioners or are content to use the hand-outs. Very few journalists in India are primarily science communicators. They jump onto the bandwagon when there is a tsunami or an earthquake or a landslide. They tend to work on the sensational angle of a natural disaster. Such events are few and far between because of which science "stories" are not a regular feature in newspapers and magazines.

However, there are a few newspapers that carry out regular features on science. The vernacular media is more susceptible to launch such regular features. There is a growing demand for scientific and technological information that is palatable to them. During such times the scientist has to be very careful. He has to cater to their urge to feed them the knowledge in a language that is shorn of any jargon, but at the same time cannot make it very light and thin. The prudish are unsympathetic to such efforts, wherein the over-simplification turns the original meaning on its head. There is also the danger of not being true to the original

sense. The print media is a great vehicle to reach out to the laity who pay the vendor to read the science. Unfortunately, the media do not pay anything or pay very inadequately to the science communicators.

The new integrated social media platform can also be harnessed to communicate with a larger audience since it provides an opportunity to effectively engage with a wide spectrum of common people comprising students, teachers, academicians, aspiring scientists and technologists, not just locally but globally. Tapping the social media encourages wide participation and greater returns on time invested. It also gives a quantifiable metric on their impact.

However, all this does not translate into a monetary benefit. When all other activities are commercialised, the task of science communication needs to be incentivised as well.

Conclusions

Science communication is a much needed intellectual exercise that needs to be carried out to pull out the general public from the morass of ignorance and intolerance to scientific and technological advances. Scientists should be more proactive in this endeavour and the journalists should be sustainable in their writings on science. The implications of scientific discoveries should be explained simply and accurately to the laity. The common people, too, need to make efforts to understand the intricacies of nature and how it behaves through the "communicative scientist". The greatest achievement of our civilisation is science and ignorance of this very vital knowledge stream does not augur well for the sustenance of all life forms.

Effective communication and reaching out to the people can be achieved through social media platforms. The tapping of this resource can widen the net and bring in more people under the fold of science "gainers". Incentivising the science communicators for their efforts need to be addressed on a priority.

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