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RESEARCH ARTICLE

SCIENCE AND TECHNOLOGY COMMUNICATION IN INDIA: HISTORICAL AND CONTEMPORARY PERSPECTIVE

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ABSTRACT

Science and Technology communication (S&T Com) is gaining increasing recognition as an area of activity, research and policy. In the Indian context, science communication covers a wide range of activities to promote rational thinking among the fellow citizens by bringing science closer to people. The paper discusses the framework of S & T communication as a discipline with academic rigour. It also discusses the roadmap for consolidation based on the rudiments of such a framework evident from the spread and depth of initiatives in progress in India.

INTRODUCTION

Five facets of science communication in the context of popularization

Science communication (Sci.Com) is an area of activity, research and policy, though as an area of research, recent in origin. One of its manifestations is science popularization. This is about public communication presenting science-related topics to non-experts, using several media. Many attempts have been made by scholars, researchers and the practitioners to define and give an operational meaning to this term "Sci.Com". Each of these definitions has taken in to consideration a broad range of criteria like the purpose, context, and theoretical development in this area at a particular time of the history, along with social and cultural and political milieu. In literature, the term Sci.Com and science populari zation has been used interchangeably by the practitioners. Even by researchers and scholars, many terms have been used i.e. "public awareness of science" "public understanding of science (PUS)", "public understanding of science and technology (PCST)", "public engagement with science and technology (PEST) or " public appreciation of science". The facets of science communication in the context of popularization are:

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- Defining Science Communication.
- Evolution of Science Popularization Around the world
- Science Communication may tend to evolve as a Academic Discipline
- Science Popularization in India
- Research Trends in Science Communication.

Defining Science Communication

Science communication (Sci Com) is an area of activity, research and policy. One of its manifestations is science popularization. This is about public communication presenting science-related topics to non-experts, using several media. Many attempts have been made by scholars to define and give an operational meaning to this term "Sci Com". As per the UNESCO's (1999) perspective, communicating science for the public means making complex ideas and concepts simpler, and creating tools to interest public without modifying scientific truth. In western literature, many terms, specially for research, have been used i.e. "public awareness of science" "public understanding of science (PUS)", "public understanding of science and technology (PCST)", "public engagement with science and technology (PEST) or " public appreciation of science". Schirato and Yell (1997) propose Sci Com as ".the practice of producing and negotiating meanings, a practice which always takes place under specific social, cultural and political conditions"

Science communication is also seen as the process of generating new, mutually acceptable knowledge, attitudes, and practices. The process of negotiation involves trust that leads to mutual understanding, rather than through statements of facts. Science Communication is a malleable tool and serves various ends for both communicators and audience (Gregory and Miller 1998). Communicating science to a public that may not be well versed in science involves translating ideas and concepts that are often extremely complex. This also has to relate to common sense in a comprehensible language to create interest in the public without altering the scientific truth (Paola Catapano, 1999). According to some researchers (Bhola *et al.,* 1989), "popularization" can be interpreted in two ways. It could mean the spread of knowledge in science and technology to citizens to bridge the growing gap between society at large and the world of science. It could also mean the acquisition of new science and technology for improving one's social and economic life. Examples of the former are knowledge about clean water and environmental sanitation, or about astronauts and space ships usually provided in science museums. Example of the latter is the understanding of new fertilizers in the rural area or the ability to master a computer in an urban setting. However, Burns (2003) gave a contemporary definition of Sci Com differentiating it from "public awareness of science" and "public understanding of Science", "scientific culture" and "scientific literacy". According to him "Sci Com is the use of appropriate skill, media, activities and dialogue to produce one or more of the personal response (the AEIOU vowel analogy): Awareness, Enjoyment, Interest, Opinion-forming and understanding". Today it is the most accepted definition among the scholars as it helps develop and test the empirical models for their efficacy in the area of Sci Com and PUC. The paper is an attempt to trace the history, manifestation and genesis of such frameworks of science communication across the world and India and its tendency to emerge as a field of academic inquiry / applications across the world. The paper also highlights the conceptual framework which has emerged over the years as a result of dedicated government and non-government initiatives. These could be considered for significant support through mutually reinforcing policies on that embed S&T Communication. An interesting frontier is about empowering citizens for informed decision making.

Evolution of Science Popularization

The historical evolution has been traced by many with different perspective like Gregory and Miller, (1998), Lucky (2000), Mahanti (2002), Masssarani, (2004), Knight (2006). Accordingly the history goes back to the time of Galileo who is credited with laying the foundation of experimental science. He strived to communicate new laws of physics and astronomy based on method of science through demonstration. "He devised suitable experiments for demonstrating his theories" He also laid the foundation of scientific method as the modern way of thinking, emphasized experimentation and reason over traditional considerations. In the 18th century, science became a source of interest and amusement for aristocracy and middle classes in Europe. With French revolution, science was used as a political tool. Knowledge of science was further consolidated through expeditions of naturalists in different part of the world. As modern ideas reached other parts of the world, especially in Latin America and Asia, popularization of science reportedly made a tentative beginning. Several periodicals and journals were created as vehicles for dissemination and discussion of science. Nevertheless, popularization of science was limited in terms of its reach to general public. The Royal institutions further intensified activities of science in terms of public lectures, demonstrations, publication of journals and books. In the second half of 19th century, science popularization activities were intensified throughout the world. Following World War II, a new kind of science popularization emerged throughout the world, for making science a major tool of development, by adopting different approaches, methods, media and strategies. For example, in USA and Europe the predominant strategies were museums and science centres - centric. Initially the public played a major role in legitimizing science itself which was replaced by the publication of specialized articles, in cognitive term, available to other specialist. This saw the mutual isolation of science and public. Some models of science communication interactions and outcomes that go beyond information access. Snow (1950) in his famous thesis on the "Two Cultures" described the gap between Science and culture in modern society. The concept of "deficit" was so popular and taken for granted; much research work in this field did not, even question the pre-suppositions on which it was based. (Martin Bauer, 2008).

One of the main criticisms against the deficit model is that it treats the difference between expert and lay knowledge simplistically as a matter of possessing or not possessing factual information (Bucchi and Neresini, 2008). In general, different evaluations of the deficit model seem to agree by now that its underlying vision of science as "a relatively unproblematic knowledge" and the public as "a body of more or less ignorant laypeople" does not do justice to the complexity of the situation (Durant et al. 2000). Within the deficit model, the PUS began to be conceptualized first in terms of scientific literacy (Bucchi *et al.,* 2008). The notion of scientific literacy refers to a minimum, threshold level of understanding of basic scientific concepts and methods "needed to function as citizens in modern industrial society" (Miller and Prado, 2000). This phase also saw the emergence of a class of professional communicators, known as science communicators. They were supposedly different from science journalists and workers in of museums, throughout the world as a result of training. These communicators are basically a link between the scientists and the lay public. However, there were such icons as Euler, Faraday, Wallace and Einstein and since 1950 Prof Yaspal and Dr. Jayant Narlikar, Stephen Hawkings , to mention a few, who also communicated and are communicating with public though their writings and lectures and face- to- face interactions. These changes in the SciCom perspective brought the subject into the very centre of science-policy interest. One of the first signals of this shift of emphasis was a 1985 report of the Royal Society in London, titled The Public Understanding of Science. It became the general label for the emerging policy paradigm (Bodmer, 1985). This statement placed the problem of "understanding" at centre-stage, as an important mediating element through which science may realize its beneficial effects on society and the economy in raising the quality of public and private decision making, and in enriching the life of the individual. It is important to note that the publication "Science Culture: Where Canada Stands" (2015) has questioned the basis of

assumptions about the outcomes stated. According to Bauer (2008), the term 'public understanding of science' (PUS) has two meanings. It brings science and people closer by covering a wide field of activities. It also refers to research that is social through which it investigates, using empirical methods, to analyze the understanding of public towards science and related variations across time and context. However, soon a substantial renegotiation of the social contract between science and society emerged. As argued by Beck (1992), there was a gradual "demonopolisation of scientific knowledge" with an outflow of potentially valid scientific truth-claims into areas external to the scientific domain. As a result, non-scientific parties become free to appropriate the language of scientific expertise, and manipulate according to their values and interests the "heterogeneous supply of scientific information. He further said "science becomes more and more necessary, but at the same time, less and less sufficient for the socially binding definition of truth." It was "not their failure but their success that has dethroned the sciences. The model of research and development governed by a largely self-regulated scientific community (representing truth), by policy makers (representing the public interest), and by industrial actors (representing consumer`s needs) seemed no longer acceptable" (European Commission 2007).

Recent considerations about applications appear to be in a continuum

The new emerging frame, public engagement with science (PEST), shifted the paradigms of public understanding and scientific literacy. It pertained to involvement of citizens in various science and technology related issues through many participatory modes and processes (public debates, campaigns, citizen panels, consensus conferences among others). As Bensaude-Vincent (2001) pointed out, in this new approach, citizens found two new roles: either as assessors of technology, or as co-producers of knowledge. In both cases, the underlying idea is that lay people may have knowledge and competencies relevant to the issue at hand, that interaction between specialists and non-specialists has to take the form of a dialogue, and that decisions have to be based on the outcome of such deliberative processes. "The changing vocabulary suggests a shift from the practice of science communication in the name of science to new practices of interaction in the name of democracy". This development had two consequences. The first was "Science for All People" - the demand for equitable distribution of the fruits of science and more equitable distribution of technological assets. Bhola (1989) elaborates this shift further: "As there is something highly immoral about a world which denies most of humanity a significant part of the collective human knowledge called science; and keeps away from those scientifically and technologically disadvantaged populations, the full enjoyment of the fruits of technology of production, communication, transportation, and health made possible by scientific knowledge and technology. Some are dying in their encounters with technology for lack of knowledge to cope with the omnipresent intruder in their lives". This approach gave space to the emergence of a new paradigm of PUS i.e. "Science and Society" and development of new model of science communication (engaging public through dialogues in two-way communication process) involving public in formulation of S&T policies and research (citizen science). Communication to reduce drudgery experienced in using certain technologies in agriculture, especially for the benefit of women farmers is a typical case in point. The second outcome was the transformation of objects of spectacular scientific achievement into objects of heated controversy, and the emergence of widespread social movements around new and controversial technological issues like GM food, Nanotechnology and their impact on society. (widespread protests against the use of nuclear energy as source of electricity, or against genetically modified foods are the immediate examples) (Geambaşu *et al.,* 2013). Thus, we see that based on the above developments, the Sci Com has moved from the scientific literacy issues, to PUS and finally to Science-in-Society paradigm. These are true also across political boundaries and developmental imperatives. Each of these phases is moved by a polemic, attributing a particular deficit, and encouraging particular research questions and forms of interventions" (Bauer 2009). Currently several other approaches are followed i.e., contextual, participatory or dialogue. The perspective of science popularization has changed with important questions pertaining to uncertainties in science, the risk and ethics associated with it. Communication of science is seen as a process of dynamic exchange; not linear or top- down, but a two-way process where knowledge, requirements, hopes and aspirations of the people must be taken into consideration. In short, since 17th century, process of popularization of science has mutated in form, content philosophical supposition, underlying culture, political and economic interests and the media available in different time and places, the actors and professionals who perform and the roles played by the public (Massarani, 2004).

Science Communication may tend to evolve as an academic discipline

The evolution of Science Communication as a discipline was started in the United States and Europe as sociology of science. Bucchi in his book "Science in Society: an introduction to Social Studies (2004) noted that "sociology discovered science as a specific object of inquiry, somewhat belatedly. Although the first studies were produced in the late 1940s it was only in 1978 that far instance, the Association of America Sociologists created a section devoted to the sociology of science. In 1976, the Journal "Science Studies" changed its name to "Social Studies of Science" and thus become the first specialized journal in this disciplinary area". Since then the discipline is flourishing. Debates on "whether science communication has become an established field of enquiry or an independent academic discipline?" and the extent to which it differs from the academics of public understanding of science however continue. Sci Com, by many scholars, is considered to be merely a sub- discipline of media studies, sociology of science and history of science as it has barrowed to a greater or lesser extent from sociology, psychology, political science, communication studies and policy analysis. Even those who presumed it not an independent academic discipline, cannot ignore the fact that it has produced a cluster of coherent and related research over the last 60 years, no doubt with strong roots from other disciplines. One may also characterize the area as bringing together relevant theoretical constructs from a variety of discipline in improving the understanding of contemporary problems. The divergence of research area, ranging from

science to society has put a restriction on number of scholars working in this area (Raza and Surjit, 2014). However "Researches in the area of public understanding of science all over the globe have resulted in creation of a large number of indicators of public understanding of science (by Bauer *et al*., Metcafe and Riedlinger 2009; Massarani *et al.,* 2005; Lee *et al*., 1995 a). cited by Raza 2014). At present research in PUS is a well established academic field in Latin America, Australia, Canada, China, Denmark, France, Germany, India, Africa, Korea, Spain, UK and Italy (Schiele Michel 2012). In his review, How to establish PCST: Two handbooks on science communication, Alessandro Delfanti (2008) challenges a claim in the book "Communicating science in social context" that SciCom already is a distinct research field. He sees in both books "an explicit effort to establish PCST as an independent academic field, different both from science and technology studies, and media theory" (Toss Gascoigne 2010). Debates are on about the elements that must be present to constitute a legitimate disciplinary field. Among such elements are the presence of a community of scholars; a tradition of history of inquiry; that defines how data are collected and interpreted, as well as defining the requirement for what constitute new knowledge; and the existence of a communication of network. Toss (2010) in his comment "Is science communication its own field?", measure the science communication against the four elements and concluded that "in the absence of sharply defined targets, we are reluctant to press hard on the this claim of science communication". But the fact which cannot be ignored is that there are many dedicated research journals on the subject ([1]Foot Note). A Google search "book on Science Communication" result in about 3,710,000 results (0.05 sec)(as surfed on 9 May 2014). A strong record (About 4,480,000 results (0.02 sec) of journal article was also indicated on Google Search (surfed on 10 May 2014). Lately, the market of science communication books has become quite lively ([2]Foot Note). as remarked by a reviewer, that " More and more books on science communication are reaching to market" (Pedro Russo2010). In parallel with structuring of the research field, formal training in science communication at university level began to take shape in the 1980s (Toss 2010) with career possibilities ranging from communication manager, public relation officer in research organizations, science writing, science journalism, employment in museums etc. At present science communication courses are offered in many countries including USA, UK, Spain, Korea, China, India Italy, and Germany, at the undergraduate, postgraduate, and degree and diploma levels. Research is also being conducted on communication models, and approaches and strategies are proposed and tested. Though there is a great deal of diversity in the in the structure and curricula of science communication programme (Crockett, 1997; Encost Team 2003; Kramer & Mulder 2006; Willem 2001) as cited by Mulder 2008. However, at present, there is an international PCST-Network, conceived in 1989, a global community of researchers, practitioners, science journalists providing an opportunity to researchers to discuss their work with practitioners. Recently the13th PCST 2014 conferences were held in Brazil, which was attended by more than 800 delegates representing more than 44 countries which attracted 559 abstracts (PCST 2014). There are networks and associations with strong tradition of science communication in their deliberations ([3]Foot Note[3]). It clearly indicates the presence of a community for this discipline. It is clear from all the above that science communication as a term, an object of study and research is well understood and widespread throughout the world, though still borrowing heavily from other disciplines. In total, as part of literature survey about 206 research papers, articles, reviews, new concepts, opinion papers, editorial and reports were scanned from a wide variety of sources. Accordingly the content relating to Science popularization/Sci Com can be categorized as:

- thods, approaches and presentations of science to people.
- Science education and informal science learning.
- Science writing, Science journalism and public.
- Communication of science by experts
- Public Understanding of Science
- Need for enhancement and creation of role models.
- Impact assessment of science popularization and other outreach programmes.
- Expressing Opinions, ideas and defining concepts for empirical observation
- (Science literacy, scientific culture, cultural distance, PUC, parallel approach, minimum science etc).
- Popularization across borders.
- Relevance of Sci Com.
- Sci Com in the past and infrastructure development.
- Analyzing skill required for Sci Com &
- Emerging Media and their potential for Sci Com.

Though, the work of science popularization and Sci Com is being carried out word-wide, recorded research in scholarly journals is very limited. In fact, the numbers of dedicated journals itself are also very limited. It has been observed that majority of studies were in the form of large scale surveys and conducted with a particular administrative agenda with a particular research protocol. Interestingly, academic discussions of public understanding of science are reviewed increasingly, across the world but seem to be influenced greatly by the American and the British experience of over the past 25+ years. In PUS studies majority of research are of quantitative in nature, measuring people's scientific literacy, attitude and appreciation for science by employing large-scale

[1] A few such well-known journals are JCOM (online journal, quarterly since 2002), Indian Journal of science communication (Half-yearly, India, since 2002), Journal of Higher Education Outreach & Engagement(all open source), Science Communication (Sage publication, quarterly, since 1979), Public Understanding of Science (Sage publication, since 2002), Journal of Scientific Temper (NISCAIR, India, since 2013), International Journal of Science Education, Part B: Science Communication and Informal Education (Taylor & Francis)(by subscription) and Study on Science Popularization and Public communication of Science and technology communication (China).

[2] A few important books published in last decade are "Science Communication in Theory and Practice (edited by Susan M. Stocklmayer at el 2001), The Hand-on-guide for Science Communicator- A Step-By-Step Approach to Public Outreach, (Lars Lindberg Christensen 2007), Handbook of Public Communication of Science and Technology (Edited by B.Trench at el 2009), Science Commutation in the world: Practice, Theories & Trends (2012) edited by Bernard Schiele et al).

[3]Organization like American Association for Advancement of Science(AAAS), Association of British Science Writers, Indian Science Writers Associations(ISWA), European event Association, Network of Museums, Australian Science Communicators(ASC), The Science Communication Association of New Zealand(SCANZ),

surveys. However as the debate on what constitutes PUS is progressing, indicators, methodology, conceptual models and even conclusions were also being put under scanner and refinement (Raza, 2014)

Science Popularization in India

India has a long tradition and history of education and training in pure and applied sciences, dating back to over 2600 years, especially in the field of mathematics, astronomy, surgery and metallurgy. Interestingly Raza (2009) argues that the tradition of original thinking and adventure of ideas and creative innovation and "knowledge was lost by the medieval period However this tradition remained confined to upper class and class intellectuals. The first efforts to communicate modern ideas originated in the west were made an inroad during the latter half of the nineteen century. A number of coalitions and some individuals in different parts of the country tried to popularize science through lectures and publication of books, magazines in vernaculars. Interestingly, Science communication in India has its origin in the scientific renaissance in the late nineteenth century in West Bengal and Punjab. West Bengal owed it to the efforts of Mahendra Lal Sarkar, Fr. Eugene LaFont, P. C. Ray, Ashutosh Mukherjee, and Jagdish Chandra Bose through the establishment of the Indian Association for cultivation of Science. Association put in efforts to take science to the people through public lectures and exhibitions. Around the same time in Punjab, "Ruchiram Sahni initiated a movement to take science to the people in Punjab by organizing public lectures. (Uncharted Terrains 2002). The tradition of science communication /popularization started during this period has assumed a dimension of people science movement today. The evolution of science communication, as finally emerged in India over the past 25 years, has been influenced by so many historical, social, cultural and political considerations. Its genesis Sci Com can be traced at two levels. Firstly it was as an initiative to fight the colonial exploitation, and after independence, to cultivate scientific temper. The society, at that time was seen by elites educated in modern western science, as steeped in obscurantism, superstitions and native culture lacking rational thoughts (Venkateswaran, 2012). In the post-independence period, in view of adoption of scienticism as the dominant ideology for national reconstruction, science was idolized as the panceas of all ills of underdevelopment and people's backwardness. Sci Com emerged as the invaluable vehicle for a rapid and complete scienticisation of the people at large. Thus, to transform India socially and economically, the eradication of superstitions was seen as a paramount task, hence, the inculcation, nurturing and promoting scientific temper, the term coined by Nehru (Discovery of India), become the national ethos and the hallmark of nation building of modern India. The concern for the same was reflected in the constitutional provision (Article 51A (h) and the S&T policies formulated in India. Indian Constitution reads as, (citizens have a duty) "to develop the scientific temper, humanism and the spirit of inquiry and reform" (Constitution of India). The Indian Parliament passed the resolution on in 1958, which was to become the guiding force in shaping Indian Science and Technology. It laid a special emphasis on cultivation of scientific temper among the common people. Accordingly, serious efforts, both at the level of government and civil society were made to popularize science and inculcate scientific temper. Just like the concept "scientific habit of mind" often used in the educational literature in USA, "Scientific temper" is frequently found in Indian discourses, though the term is subjected to varied and diverse interpretation (Venkateswaran, 2012). During the mid 1990s and onwards, it become was very clear to our political leadership, policy makers and planners that "people cannot play the role of global citizen in the era of globalization and liberalization, if they are not scientifically literate and attitudinally rational" (Tyagi, 2006). The concerns were reflected prominently in Policy (2003) and then in the latest Science, Technology and Innovation Policy (STI) 2013, which clearly spelt out the importance and commitment to support S&T communication/ the public awareness or understanding as the world used in STI 2013policy. The S&T Policy 2003 mentioned in its objective as follows: "To ensure the message of science reaches every citizen of India, man and women, young and old, so that we advance scientific temper, emerge as a progressive and enlightened society, and make it possible for all our people to participate fully in the development of science and technology and its application for human welfare. Indeed, science & technology will be fully integrated with all sphere of national activity. It is further stated that: "Every effort will be made to convey to the young the excitement of scientific and technological advances and to instill scientific temper in the population at large". "Support will be provided for programmes that seek to popularize and promote science & technology in all parts of the country. Programmes will also be developed to promote learning and dissemination of science through the various national languages to enable effective science communication at all level36. STI Policy 2013 unveiled at 100th Indian National Science Congress further re-commits to science communication in its section, "Public Awareness and Public Accountability of Indian STI Sector" in following words, ""Public understanding of science is an important dimension for introducing and reaching the benefits of modern science and technology to the people. The civilization aspects of science, or scientific temper, needs to be promoted across all section of the society systematically. Effective science communication methods, by using tools such as the National Knowledge Network, will be initiated."

"Public and political understanding of science should be based on evidence and debates with open mind. People and decision makers must be made aware of the implications of emerging technologies, including their ethical, social and economic dimensions. White papers on mission-oriented programmes, with specific deliverables and timelines, will be published. Mechanisms for assessing the performance of the national STI enterprise through an autonomous and robust evaluation system, which includes social scientists, will be established. The national science academies will be accorded a major role in this endeavor of public accountability"37. A.P.J Abdual Kalam (2010) in his inaugural speech during 11th PCST 2010 Conference, organized in India (Delhi, 6-10 December 2010) reasserted the above concerns: "powerful science communication is an asset to the transformation of society" and laid an agenda before science communicators to take up three tasks i.e.

- To make all citizen to feel the excitement about science,
- to make all citizen to know about the advancement in science and their role in society in economic and health

development and to bring more fruits of science within the reach of their daily life, while being sensitive to the sustainability of our planet and our responsibility towards it and

- To motivate students and entice them to embrace science as profession38

The Indian Sci Com system made a modest beginning in the 1950s through such popular science magazines as Science reporter and Science Ki Duniya by National Institute of Science Communication and Information Resources (NISCAIR), (at that time Publication and Information Division), media coverage, and publication of original and translation of imported books into local languages. At the same time, some non-governmental organizations (Science writers and social activists) realized the importance of communicating science in mother tongue. This over the years was to give birth to people's science movement (Pattanik Binay K and Sahoo) with massive government support and vast participation of voluntary groups. Indian Sc com system's large scale manifestation occurred through well-conceived strategies of (i) institutional development; (ii) nation-wide activities and campaigns; (iii) setting up of science and eco clubs at the grassroots; and (iv) strengthening popular science-media interface. In 1978, the National Council of Science Museum was created to popularize S&T for the benefit of common masses by erecting museums in various parts of the country and organizing exhibition, seminars, popular lectures, science camps among others([4]Foot Note). In 1982, with a view to consolidate, coordinate and catalyzed and support the effort of science popularization/communication at the micro and macro level in the country, the Govt. of India established the National Council For Science & Technology Communications (NCSTC) as apex body.([5]Foot Note) Again in 1989, Vigyan Prasar, an autonomous body under the Department of Science and Technology, Ministry of Science and Technology, has developed itself into a national resource-cum-facility centre; and is developing a variety of software, utilizing different means, media and modes (VP Annual Reports 2010-11). The specific mandate of these agencies gave a definite direction for the development of conceptual framework of S&T communication/popularization in India. National campaign to built and maintains the bridge between science and the people are now more frequent and effective in science communication. A series of such examples are BJVJ(1987) and BJGVS, programmes built around the natural phenomena (Total Solar Eclipses, Transit of Venus 2004, 2012 etc), Year of Scientific Awareness-2004, Vigyan Mail/Science Express (Science Exhibition on Wheels"), Year of Planet Earth-2008, International Year of Astronomy (IYA 2009), Year of Biodiversity 2010. (Annual Report Vigyan Prasar 2009-10 and 2010-11).

[4] The National Council of Science Museum has built 40 regional and district science centres with the national centre located at New Delhi. See Raj, Ashok (2012), Developing a Database and Website on Permanent Science Popularisation Sites and Strategies for promoting their Popularity and Utilisation, project catalysed by NCSTC: Also see sciencemuseums-ncstc.in

[5] The NCSTC was the result of The Working Group on S&T for the 6th Five Year Plan (1980-1985), which in its report stressed the need for creating an institutional mechanism to promote and facilitated the dissemination of scientific temper in society. Science Advisory Committee to the Cabinet (SACC) considered this matter and recommended its creation, which was constituted by the Government in May 1982

These largely participatory activities are built around celestial events (Eclipse, transit of Planets etc), low-cost/no-cost models, teaching aids and toys, training modules for supplement formal science education, S&T for visually challenged, and networking of Govt./Non Govt. organizations for S&T communications. The National Children's Science Congress, first of its kind and unparallel in the world of science, is being organized by the NCSTC, for the last eighteen years in the country. This unique programme has already caught the imagination of a few Western and West Asian countries. In this programme, some 6, 00,000 children participate every year (Tyagi2012). The Vigyan Prasar Network (VIPNET) of Science Clubs – mostly in rural areas, with nearly 12,000 member clubs as of today, has laid the foundations of a national science club movement (Annual Report Vigyan Prasar, 2012-13). The Ministry of Environment and Forests have also established a countrywide network of Eco-clubs established to spread awareness about conservation of environment, biodiversity and sustainable development (Annual Report MoEF, 2012). Bedsides that many state level network and organization are playing a very important role by talking up local science issues. Media engagement with prospective audiences has remained an indispensable –part of the country's Sci Com. Regular programmes are being aired on television and AIR on various aspects of science and in major Indian languages. Several AIR stations with science cells broadcast three programmes per day. Doordarshan – the National Television Channel - telecasts about two programmes every week on the national network and all regional centers put together produce and telecast some 150 S&T programmes every year. Agencies like University Grants Commission, Central Institute of Educational Technology, Indira Gandhi National Open University, and Vigyan Prasar also have regular slots on Doordarshan. Programmes on S&T Popularization for telecast/broadcast are also produced by several Government/Non-Government agencies. S&T coverage in the newspapers/magazines is also steadily picking up. Popular science magazines have proliferated in several regional languages (Vinay Kamble). Vigyan Prasar has also set up a network of satellite interactive terminals spread throughout the country exclusively for S&T communication using Edusat, India's satellite for education. Print media and the Internet are also being utilized by Vigyan Prasar for science popularization (Annual report (VP, 2010-2011).

Two research journals dedicated to Science communication are the "Indian Journal of Science Communication" by NCSTC and Journal of "Scientific Temper" by NISCAIR are being published. Dream 2047 and VIPNET news (published by VP) and NCSTC Communications a news letter of NCSTC have also played a significant role in introducing new indigenous concepts and ideas relating to science popularization and Sci com. A survey was undertaken by NCSTC, DST in 1989 about the job opportunities in the area of Sci Com in next ten years (Indu Puri, 1992). As the result of these programmes, a conceptual frame has been evolved, which had attracted an increasing number of adherents both among the common people and among communicators, cutting across several divides including the urban/rural. (Seghal, 2011). Based on the annual reports of last 15 years of various departments and agencies, the kind of programmes and activities undertaken can be classified under following heads:

- The construction of science-and-culture installations like Science Museums, Science Cities etc and creation of specialized agencies for SciCom like NCSM, NISCAIR, NCSTC and Vigyan Prasar
- Emergence of a new class of professionals, trained through various short term and long term training programmes and courses
- Development of S&T communication software and its dissemination (Audi- video, exhibitions, films, publication of book, journals, activity kits, CDs).
- S&T communication networks/systems and coordination with the other agencies.(Networking agencies for nationwide programme involving both government and non-governmental agencies)
- Field based programmes (Involving large number of people through national campaign like BJVJ,BJGVJ, International Year of Physics 2004 etc)
- Research in S&T communication.(For large scale surveys, impact assessment tools etc)
- Incentive schemes (Awards and Prizes for best efforts in S&T Communication) &
- Policy and Planning in science communication

The Conceptual Framework of S&T Communication in India

After examining of various field project reports (of national, regional and state level), research studies, editorials of various journals and magazines (NCSTC Communications, Dream 2047, Vigyanik Drasthikon, Indian Journal of Science communication, Journal of Scientific temperament), books, (Vigyan Prasar, CSIR, Publication Division, NBT, CBT, NCERT among others) book reviews, popular articles, news columns, discussion forums, blogs, websites, proceedings of seminars and symposia's, annual reports and publication brought out by various government and non-governmental bodies/agencies, the conceptual framework which could be constructed has following in built features at content and methodology level:

At the Content level

In context of science communication, the word science has often been used to convey a meaning which covers a much wider canvas than what it does when one talks about in conventional sense. The word "Science" in science communication, therefore would not only cover physical or biological science, it would also take in their basic, applied and environmental aspect, together with their social, societal and economic dimension as well as their inter-relationship". Hence "S&T communication is not only flow of scientific & Technological information and facts from source to target group through some medium." "It also includes spreading and nurturing of scientific temperament/ values and method of science". "Mere dissemination of scientific information and facts is not to be confused with the main objective of science communication, or even of science popularization (Seghal N.K. 2011). In fact this can be a small, albeit an unimportant, component of the whole thing". Science-communication should aim at conveying that

- "Science is everywhere: at home, out in the open, at school, on the way to or from school and all around them; anything and everything that we touch, feel and experience has to do with one or another aspect of science".
- "Anyone and everyone can use the knowledge and the tools provided by science to one's and society's advantage."
- "Increasing adoption and internalizations of the method and values of science in every-day life can help one get more out of one's resources through their optimal utilization."
- "Research in S& T communication include development of field level projects with a view to studying and researching various existing impediments to the spread and promotion of scientific outlook/attitude/temper among people; and devising and developing more effective communication methods, means, tools, techniques and technologies than those presently in use".
- Development of evaluation methods and mechanism for determining the efficacy of various tools employed for S&T communication
- Pools and survey to assess levels of S&T and attitude among various section of the population.

Accordingly, science communication ought to focus more on conveying the basic approach, the attitude, the method, the processes and the values of science and less on its content, facts and information (Tyagi, 2006).

At the Methodology Level

Important characteristics of Strategies and methodologies used for S&T Communication are that Science communication on the whole and in overall Indian context includes a critical examination and assessment on a scientific basis of its age-old tradition in different areas (viz; agriculture, health, education etc), especially before entirely new or parallel things are sought to be promoted by way of dissemination of information. (Contextual approach), use of all possible media, modes and methods of communication traditional, non-traditional , electronic, non-electronic, including folk forms for effectively conveying messages and information; for discussion, debate and exchange of experiences;

Use of the local language and idiom in all communication especially folk forms;

Use of Interactive and participatory form of communication. Emphasis on the learning-by-doing method and on low or no-cost activities which employ common and easily available local material; (decentralized and engagement/participatory approach) and a conscious effort to make communication as much of a two way process and preference to those methods and media, which allow more of this. (not top-down or linear approach) wherein science is seen as a process and a method rather than a mere branch of knowledge. A basic assumption that the communicators, in the process of science communication, also have a lot to learn more those whom they would be trying to reach or communicate with- even in the case of those who might be illiterate in common parlance. (Dialogue approach)

Preparing large number of resource persons through training in the preparation and use of common software materials prepared centrally as well as at the local level. In India science communication is taken up mainly by two approaches, formal approach, also called modern approach, actually western in origin, rooted deeply in science museum, science city, science exhibitions (fixed & mobile), which are capital intensive and highly centralized (Sehgal) The other approach, termed as informal or indigenous "parallel approach", which is decentralized, activity based, low cost, participation-intensive by voluntary groups. Though, the concept of formal and parallel approach has not been elaborated by any researchers but the same is being adopted by the practitioners in all the outreach progrmmes and activities of the voluntary groups As seen in the earlier sections, the Indian Sci.Com system has been largely built on the following set of approaches: Contextual approach; Decentralized and participatory approach; Not top-down or linear approach; and Dialogue approach. Thus, the Indian Sci Com system is highly relevant, carrying indigenous images of science and science communication, "which are more suitable and effective as per the socio-cultural milieu of a highly diversified country like India". The basic premise and the strategies of parallel approaches to achieve the goal of SciCom, evolved over the past 25 years period can now be stated as follows:

"For any S&T communication and popularization programmed to be effective, it has to be participatory, interactive and in a language employing an idiom which belongs to those one is trying to reach, or communicate with."

"In any interactive S& T communication, the communicators involved too, have much to learn from those whom they may be trying to communicate with, even if the latter may not be either literate' or formally educated.

Research Trends in Science Communication

In 1950's, first survey for measuring attitude towards science and scientists was conducted in the USA. "Since the 1970s, many countries have undertaken audits of adult scientific literacy the US, Canada, China, Brazil, India, Korea, Japan, Bulgaria, Switzerland, Singapore, Britain, Germany and France and many other EU countries". A list of such efforts was compiled by Martin W. Bauer. Resultantly some empirical indicators of PUS has been emerged by the work of Martin Bauer, Nick Allum and Steve Miller (2007), Metcalf and Riedlinger (2009), Massarani et al (2005) (Raza *et al.,* 2004). Various methodologies, conceptual model and statistical tools have been applied to collect and analyze the data, which differ country to country. These sub-sets of exploratory endeavors which are so diverse in nature have always put a big challenge to researchers to explore more. Despite that the research and surveys are being conducted regularly to measure the scientific literacy and public understanding/interests/attitudes to science. However, the researching paradigms of PUS has undergone a change over the years from science literacy to public understanding of to participatory and engagement model. But as observed by Bauer, Martin W, "Each paradigm has its prime time, and is characterized by a diagnosis of the problem that science faces in its relation to the public. A key feature of each paradigm is the attribution of a deficit either to the public or to science. Each paradigm pursues particular research questions through survey research and offers particular solutions to the diagnosed deficit problems". In 1991, in India first study was taken up in Kumbh Mela in Allahabad (Bhattacharya 1983) by CSIR and NCSTC (Department of Science and Technology). This was followed by a series of studies during Ardh Kumbhin and Kumbh in 1995, 2001 and 2007. (Raza at el, 2009) Time series data were collected and based on the analysis of data, a cultural distance model, an empirical method for mapping understanding of science was proposed (Raza at el 1996). The method has also proved useful in estimating the shift that has come about in PUC of a given set of population over a period of time. The Indian Science Report 2005, (Shukla 2005), was another effort of its kind, to present the state of science and technology in quantitative terms. The report also gave an insight about public understanding of science or science communication. It draws very interesting inferences as regards public attitude towards S&T. "Over three fourths of the public feel that S&T is important for education; and believe that S&T makes lives healthier and more comfortable". On an average, the level of knowledge the population has about the scientific concepts is very high". No doubt, Sci Com has been established itself worldwide as a legitimate field of inquiry, drawing attention of both, policy makers and media. However, the basic communication models predominantly remained deficit. In practice, what is being communicated, is informing the public about the basic science, helping laypersons understands that what is already known, improving their understanding of the process by which science is conducted and engaging them in science activities like exhibition in museums, science centers and science outreach activities conducted through youth-and –community based groups/ organizations. "bringing science close to people, and to promote public understanding of science in the tradition of public rhetoric of science (Fuller 2002 for the idea, Miller et al for attempted inventories of such initiatives).

Challenges/opportunities for locally adapted investigations that need to be addressed on a priority basis

As Sturgis describes in his essay (cited by Jack Stilgoe, 2014), several models of engagement are often discussed, albeit with limited empirical evidences. This corroborates Sturgis's statement that "we know rather little about whether the public are as keen on participatory dialogue. We need to question the constructed publics that are being invoked in the discourse and practice of engagement through popularization. (Wynne, 2006). This is related to Jasanoff's argument that publics are not alike and are guided by culturally conditioned 'civic epistemologies'". This calls for detailed investigations on the microcosms of publics and their abilities / preparedness to responds to science popularization calls. In the same vein, Cooter and Pumfrey (1994) indicate that popular science has long suffered a false sense of coherence with approaches of authorized science. This is true even for the very framework of popularization and its interpretation. The above arguments suggest the need for entirely new approaches to investigations on science popularization; however, through a symbiosis existing and emerging frameworks. As Bhola says, there is an urgent need for communities to link tradition with the wisdom of the scientific approaches. These could be mutually reinforcing and not always antagonistic. It is essential to

therefore define these synergies on a case to case basis. Detailed reality checks are inevitable in this context. Language and cultural diversity in India lend themselves to such reality checks that can generate valuable insights that can be applied for appropriate integration in comparable circumstances in other countries. Insights from decentralized, non-linear model of science communication practiced in India have to analyzed with greater vigour and aligned with concepts of science communication prevalent in many parts of the world. For example, the annual event National Children Science Congress has caught the imagination of a few western and west Asian countries. A case in point is China ([6]Foot Note) with campaigns with the help of school children to overcome superstitions and attempts are made in England at communication S&T through science plays and other tools (Hepeng Jia and Li 2014).

Comments by the Author

The studies of the nature proposed above directly relevant for the success of communication strategies is progress in India. Arguably they can also guide reporting on India's preparedness to understand and aligned with communication requirements embedded in bilateral and multilateral arrangements. Most importantly paper has added value to the discussion on communication pathways and expected impacts; whereas science communication/popularization agendas are integral parts.

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[6] China, which, despite very different political institutions and democratic norms from those in Europe and the US, has seen a wave of pilot projects of public participation in science, including the country's first pilot consensus conference. See Hepeng Jia and Li

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