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Institutional narratives and their role in communication of science and technology: a study of public science museums and centres in India

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Abstract

This dissertation looks at the narrative of science and technology promoted by national level public institutions which work in the field of science communication and public understanding of science. Focus is on India and specifically on the National Council of Science Museums (NCSM hereafter), which is a centrally funded organization under the Ministry of Culture, Government of India. It oversees the creation of many science centres around the country and manages several of them. The organization has a clearly defined set of goals and objectives, the most prominent one of which is the 'promotion of scientific temper' (a recurring theme dealt with in the chapters), and is in charge of carrying out multiple programmes of public engagement with science, the details of which can be found in the annual activity reports. These constitute a part of the primary literature used in the dissertation. Interviews carried out with highly involved stakeholders (like the NCSM management), field notes gathered during museum visits and other publications of NCSM and contributions of NCSM professionals to academic discourse constitute the other primary sources.

The dissertation has four chapters. The first chapter discusses museums in India, providing a brief history of the institution beginning with its colonial origin. It continues with a discussion on public perceptions of museums in India, analysing the results of an online survey with about 90 responses. It also introduces some arguments regarding the history of NCSM (thereby connecting it to the second chapter) and shows why the NCSM deserves to be studied. In the second chapter, the Council is examined in depth as a national institution which draws public money for its management and activities, and positions itself as one of the leading science communication institutions in the country. The goals, objectives, structure and functions are explained stressing the fact that this centrally managed organization with several subsidiary units spread across the vast territory has few parallels around the world. Special focus is on the history of the science museum movement in India and NCSM's role in it. The proliferation of the science centre model of communication is explained in conjunction with a reflection on global trends which affected the science museum space. In the third chapter, one of the national units of the NCSM, the Birla Industrial and Technological Museum in Kolkata is taken up as a case study to understand the various activities of the NCSM. Existing literature on science communication and education practices is considered alongside data collected at the site to understand how the NCSM (and BITM) speaks to its public. Finally, the fourth chapter looks at the emerging narratives of local and national cultures and histories of science, technology and society in science museums and centres. Secondary literature from heritage studies and history of science is used to understand how heritage and history can be used and have been used as powerful anchors to narrate stories of science and technology. The chapter also discusses the national narrative of science and technology that emerges from the NCSM's rhetoric and activities.

Introduction

This dissertation looks at the narrative of science and technology promoted by national level public institutions which work in the field of science communication and public understanding of science. Focus is on India and specifically on the National Council of Science Museums (NCSM hereafter), which is a centrally funded organization under the Ministry of Culture, Government of India. It oversees the creation a large number of science centres around the country and also manages several of them. The organization has a clearly defined set of goals and objectives, the most prominent one of which is the 'promotion of scientific temper' (a recurring theme dealt with in the chapters), and is in charge of carrying out multiple programmes of public engagement with science, the details of which can be found in the annual activity reports. These constitute a part of the primary literature used in the dissertation. Interviews carried out with highly involved stakeholders (like the NCSM management), field notes gathered during museum visits and other publications of NCSM and contributions of NCSM professionals to academic discourse constitute the other primary sources. Field notes, archival materials and interviews collected from the two periods spent at the Museo della Scienza, Milan and the Smithsonian, Washington DC will also be used to highlight communication practices around the globe and to discuss international collaborations of the NCSM (in the case of Smithsonian).

Science and the Indian state: a background study

In a 2015 news feature[1] carried in *Nature*, Indian science journalist TV Padma listed some of the highlights in India's road to becoming a science superpower and some of the major structural and societal challenges that have been impeding the country from fulfilling its technological, industrial and economic potential. Several of the major achievements, as the feature discussed, have emerged from the fields of space research (the Indian Space Research Organisation, or ISRO, completed its Mars mission by successfully sending the

1 Padma, TV. (2015). India: the fight to become a science superpower. *Nature 521* (7551), 144-147.

Mars Orbiter in its very first attempt in 2014 at a small fraction of the cost incurred by other space research agencies in the developed world), the pharmaceutical industry (India produces a large volume of low-cost medication and vaccines) and renewable energy (there is increased focus on making India a major solar power; it already is a world leader in wind power). However, the list of challenges for a country with a population of approximately 1.25 billion people is immense and often seems to outweigh the positives. Padma notes that the problem starts at the very top and is a result of a lack of political will. Successive governments, while pledging to financially support the Indian scientific community, have not significantly increased the budget for research and development, which has lagged at about 0,9% of the GDP (with a conspicuously less investment from the private sector) significantly lower than other BRICS economies. The education quality at the universities, save for a few which receive central government patronage, has also been not up to the mark to produce world-class research. India has one of the lowest densities of scientists and engineers in the world, which can seem surprising as the country also produces many scientists and engineers who then move on to different parts of the world, especially in the US. Brain drain has been a cause for concern in the Indian society, as some of the most qualified among Indian students continue to move out of the country in search of better opportunities. Then there are also continuing societal challenges such as concerns over public health which pose significant threats to a vast majority of its population, like maternal deaths, malnutrition, high incidence of tuberculosis and malaria. And yet, the Mèdecins sans Frontières (Doctors without Borders) terms India as the 'pharmacy of the developing world' because of its significant output in low-cost drugs. It is also evident that the aspirations of young India are rising, as every year the number of students enrolling in higher education increases. But state support is not sufficient to ensure the students get world-class education. Scientists and entrepreneurs have suggested the need to enhance ties between universities, research laboratories and industries, and the government has started paying heed to those calls by setting up incubators and supporting start-ups which can help transfer knowledge from research facilities to the industries.

However, for a country as big and complex as India, with many inherent contradictions and paradoxes as mentioned above, solutions cannot only come from the top and from the

experts. In yet another *Nature* commentary, Sunita Narain, the Director-general of Centre for Science and Environment, New Delhi talked about the need to fix more pressing needs like sanitation using innovative, bottom-up solutions. She said:

> The key obstacle is that everyday challenges are not top priorities for research and innovation. Indian science has always been fascinated by the 'masculine' agendas of space and genetics, not reinventing the toilet.
>
> Instead, science must meet the needs of poor people. We need to devise ways to prevent pollution rather than cleaning it up afterwards. Indian research has to be more humble, nimble and investigative. It has to learn from its poorest and most illiterate people: how they cope with scarce and diverse resources by being frugal and in tune with their environment.
>
> India's ambition should be to become the front-runner in the race to save the planet.[2]

There are two key issues that emerge from Narain's comments: the need to pay attention to people (often from the most vulnerable sections of the society) and their innovative solutions; and the role that India must assume in the global debate on environment and society. The fact that these issues have resonated with Indian policy makers can be corroborated with the most recent government science policy document titled *Science, Technology and Innovation Policy* (2013), which discusses the aspirations of India for 'faster, sustainable and inclusive growth' (p.1) and the role of the huge potential talent pool that India's largely young population offers in achieving it. At the very outset, the policy document also mentions briefly what the previous policy statements set out to achieve. In the history of independent India, three such policy statements were published in different years before the 2013 one. The very first policy of 1958, placed great emphasis on science and scientific research with the assumption that technology would flourish from the scientific infrastructure. The next document *Technology Policy Statement* of 1983 discussed the need to become self-reliant and technologically independent, thereby placing the emphasis this time on technological development. In 2003, the government proposed a

2 Research management: priorities for science in India (2015, May 13). *Nature 521*(7551), 151-155. doi:10.1038/521151a

Science and Technology Policy where the two were brought together and the need for investment in research and development was highlighted. This is also the first time the idea of a national innovation system had started to emerge in a policy framework. The 2013 document makes it clear that the focus will be on people, and that the national science, technology and innovation (STI) system must recognize the society as its major stakeholder. Thus, the 'emphasis will be to bridge the gaps between the STI system and socio-economic sectors by developing a symbiotic relationship with economic and other policies'. (p.3) To empower people and incorporate them into the STI framework of the country, one of the suggestions as proposed by the policy document is the promotion of scientific temper amongst all sections of the society. The concept of scientific temper and its promotion among the public is the cornerstone of science communication policies in India. In this dissertation, this concept will be discussed at great length and depth, starting with the history of the term, its continued prominence in science policy documents, and how it is envisioned by major public institutions in charge of science communication, namely the National Council of Science Museums (NCSM), India, which forms my primary case study. However, the centrality of this phrase to the arguments carried in the dissertation necessitates an early introduction and discussion of it, before the focus shifts to the description of the main case study.

Some preliminary thoughts on scientific temper

'Scientific temper' was first officially mentioned in Jawaharlal Nehru's *The Discovery of India* (1946), a monograph he wrote while imprisoned with other leaders agitating against Britain's rule over the country. Presented as a part-autobiography, part civilizational history of India, the patriotic overtones would be evident to any reader. While recounting India's many existing social problems, like poverty, overt religiosity, superstition and caste system, Nehru (1889-1964), who received an undergraduate science degree in Cambridge and was trained in Western traditions of Enlightenment, emphasized the need to cultivate scientific thinking in order to approach life and its challenges. He explained that

> The applications of science are inevitable and unavoidable for all countries and peoples to-day. But something more than its application is necessary. It is the

> scientific approach, the adventurous and yet critical temper of science, the search for truth and new knowledge, the refusal to accept anything without testing and trial, the capacity to change previous conclusions in the face of new evidence, the reliance on observed fact and not on pre-conceived theory, the hard discipline of the mind—all this is necessary, not merely for the application of science but for life itself and the solution of its many problems. (Nehru 1946, 512)

It is important to pause here and reconsider the phrases 'scientific approach' and 'critical temper of science'. David Arnold, historian of science at Warwick University, commented that not only did Nehru recognize the material and practical benefits of foregrounding science and technology for the development of a nation, he strongly argued for science (scientific method and approach) as a 'philosophical approach' (Arnold, 2013) This, I argue, following the work of historian David Arnold, is the enduring legacy of Nehru and his contribution to postcolonial scientific debates: the shift of understanding from science and technology as an imposition of Western authority to science and technology as answerable to the state and the public[3] for its capability of delivering a better, inclusive, humane society, as well as the point of time in which this idea emerged, ie.in 1946, just before India's independence. As Indian science communication scholar, Gauhar Raza further noted in a lecture delivered at the Durban University of Technology in South Africa in 2015:

> The debate that followed the publication of his book was intense, for three reasons. Firstly, Nehru, politically the tallest leader of freedom movement, himself popularised the phrase and used it often during his speeches, secondly, the growing scientific community found an opportunity to expand and participate in building the future country, and thirdly, the notion was sufficiently nebulous and could be

[3] The public and its relation to science and technology forms the crux of the debates in the multidisciplinary and interdisciplinary fields of science communication and public understanding of science. It is one of the major frames that will be taken up especially in Chapter 3, where I will discuss the various activities (in and outside galleries) of the Birla Industrial and Technological Museum, one of the main constituent museums of the National Council of Science Museums (NCSM) which forms my primary case study in the dissertation. Both institutions will be introduced in the next pages.

used politically to oppose the superstitious reactionary-unscientific ideas prevalent in the society.[4]

The post-Nehruvian period in Indian politics and policy-making saw a growing interest in the concept and its increasing importance in the mandate of several public institutions working at the interface of science and society[5] (Tyagi, 2014) including those which were in charge of promoting scientific literacy and popularizing science. Scientific temper was also interpreted as a rejection of unscientific, irreligious or superstitious beliefs often fostered by organized religion(s)[6]. The inculcation of scientific temper was added in the Indian Constitution as one of the ten fundamental duties of every citizen under Article 51(A) (H) by the 42nd constitutional amendment, 'to develop the scientific temper, humanism and spirit of inquiry and reforms'. This took place in 1976, and India became the first country to include such a clause in its Constitution. It is also to be noted here that the period in which this amendment was carried out was during the rule of the Congress Party, with Nehru's daughter Indira Gandhi at the helm of the government. As David Arnold argued:

> As state policy, NS [Nehruvian Science] reached a new plane of authority under the premiership of Nehru's daughter, Indira Gandhi. In 1974 a statement on national science policy was written into the fifth of India's five-year plans, followed in 1976 by an amendment to the Indian Constitution that made it the duty of every Indian citizen "to develop the scientific temper." These moves arguably reveal more about

[4] Durban University of Technology. (2015, September 17). Prof Raza talks on 'scientific way of life' in India. See http://www.dut.ac.za/prof-raza-talks-on-the-scientific-way-of-life-in-india/ (last accessed February 2017). I have indicated the last accessed month throughout the dissertation because web links are highly unstable.

[5] Tyagi, BK. (2014). Fostering scientific temper. *Vipnet News 12*(2), 1-3. See http://www.vigyanprasar.gov.in/vipnet/february-2014/Vipnet-february-2014.pdf (last accessed January 2017)

[6] The Preamble to the Indian Constitution states that India is a sovereign secular socialist democratic republic. The word 'secular' is noteworthy in the Indian context because of the presence of multiple faiths and religious practices among the Indian population. However, one of the persistent issues with organized religion has been the parallel establishments of extra-scientific practitioners, including astrologers and self-fashioned godmen/women who continue to wield immense power among many sections of the people, not only in the villages. Multiple discussions on scientific temper have addressed this issue as the root of many societal problems, and the reason why the promotion of scientific temper must take place in all sections of the society.

> Mrs. Gandhi's determination to consolidate her political position as her father's heir than the actual pursuit of science. (Arnold, 2013)

Apart from the role of the term in the politics and policies of Congress Party, it also continued to gain currency among leading scientists. In 1981, a statement on scientific temper was issued by a group of intellectuals and academics, which discussed the virtues of scientific method as an antidote to religious and superstitious belief. The statement discussed 'scientific temper' as a method of science which encompasses all knowledge (not only natural and social sciences) and explained that in a vastly inegalitarian society, the idea of every citizen inculcating scientific temper would remain a distant dream. The statement recognized the aspirations of the population and called for a role for scientific temper to revive confidence and hope and dispel fatalistic notions. This statement was revisited in the 2011 Palampur Declaration which mentioned that the discussion on scientific temper has not been taken up at a massive scale as it should be by scientists and academics (including social scientists). Unlike certain academics (Matthews, 2015; Raza et al, 2014) who located the origin of Nehru's 'scientific temper' in Western traditions of rationality, the Declaration pointed out that "The tradition of skepticism and humanism is not new to Indian intellectual tradition. Such notions go back to antiquity – Jain, Sankya[7], and Buddhist traditions have repeatedly emphasized the spirit of enquiry. During the Indian Renaissance many leaders popularised the notion of scientific enquiry and gradually it became part of Indian ethos." (p.1) Evidently, the document proposed to look at the concept as an Indian legacy. In this dissertation, my attempt therefore is to engage critically with the rhetoric of scientific temper and examine how it has become a part of institutional narratives and have been operationalized by public enterprises. Also, it will be interesting to study the phrase as an enduring legacy of the independent Indian state, an argument I will posit in the fourth chapter where I will discuss the role of narratives of local, regional and national cultures in science communication.

To understand how contemporary public institutions perceive and operationalize the

[7] The Sankya or Samkhya tradition, is considered as one of the atheistic traditions in orthodox Hindu philosophy, which analysed the world in a dualistic scheme: that of nature and people, both independent of each other. It is also a tradition that argues about valid sources of information and the importance of perception and inference.

concept, I have selected the National Council of Science Museums (NCSM), Kolkata as my case study as it is identified by the government as one of the leading institutions in India for science popularization, communication and education, evident, for example, from the fact that the Ministry of Culture which funds its activities and its administrative running costs allocates the highest share of its budget to NCSM[8], when compared to other institutions of national repute (including museums which are not under the NCSM management, libraries, archives, education institutions) also engaged in the task of promoting Indian cultural heritage. It is important to note here that I was already keen on carrying out research on science communication to the public in an emerging technological power like India, and had decided to focus on Indian science museums, because the topic has received very little academic attention. However, at the very outset, while looking through websites and reading activity reports of NCSM which are freely available online, it became clear that the institution considered 'scientific temper' as a key phrase in its aims and objectives. Thus, it was important at that stage to not only read relevant literature in museum studies, science communication and public understanding/participation in science but also understand the concept of scientific temper as a crucial element that both defines and sets apart the Indian example from the rest of the world.

Interrogating the institution that is NCSM

As mentioned earlier, the National Council of Science Museums, or NCSM, will be the main case study in the dissertation. Established in 1978, the NCSM is the largest consortium of science museums and centres in the world. Funded by the Indian Ministry of Culture, it manages 25 museums and centres at present, and further to that, has created and is in the process of creating several more centres around the country, which it then hands over to the respective regional governments for management. While the history, structure and functions of NCSM will receive substantial attention in the dissertation, especially in Chapter 2, it is important to introduce the institution here to further the

[8] See pages 9, 34, 35, 265-267 of the Ministry of Culture Outcome Budget 2016/17 for further information on NCSM and its budgetary allocations: http://www.indiaculture.nic.in/sites/default/files/budget/Outcome%20Budget/2016-2017/Outcome%20Budget%202016-17%20(English).pdf (last accessed February 2017)

discussion on the various analytical frames that will be employed to understand its role in science communication and promoting a specific (national or otherwise) narrative of science in India.

The first governmental attempt at defining India's scientific heritage and to promote science education was the establishment of Birla Industrial and Technological Museum (BITM hereafter) in Calcutta in 1959, in the decade following India's independence. As Saroj Ghose, the first Director-General of NCSM and former president of ICOM (between 1992 and 1998), explained in a personal interview, the need was felt by the central and state governments, and especially by the then Chief Minister of West Bengal, Dr Bidhan Chandra Roy, to preserve artefacts of historical significance in the newly formed state. He was to a great degree influenced by the set-up at the Deutsches Museum which he personally visited and from this institution he drew inspiration to form a similar one in India.

Soon however, the opening of the Exploratorium in 1969 in San Francisco and the Ontario Science Center in Toronto challenged the existing concept of science museum, where the focus had so far been on the history of scientific objects/instruments and the narration of a country's heritage in science and technology. Science communication scholar and museum expert Bernard Schiele noted: 'These two science centres were the first resolutely to make communication with visitors their primary objective. Until then, the science had been the prime focus of attention, and communication was a tool to serve scientific knowledge; from then on, communication would take precedence, with the intention of raising interest in science and helping to achieve science literacy.' (Schiele 2008, 32-3)

The Exploratorium model of hands-on approach to science communication strongly favoured science education and active participation in understanding of science. As Ghose explained further, for a young country with its policies firmly grounded on the needs of it becoming self-sufficient, and to educate its large rural masses, the choice of model of science communication had to be one where education was foregrounded rather than science appreciation. The success of Exploratorium and the growing interest in activity-based science training also to cater to the needs of the rural population combined to create a major motivation for science museum professionals in India to propose this new

institution as the most suitable model for science communication, which resulted in the formation of the National Council of Science Museums (NCSM) in 1978.

The developments that took place in India in the 70s mirrored the changes that the science museum as an institution was undergoing around the world, even though it must be noted that the science museum as a space for storage and display of the history and heritage of national science had a far longer presence in the West than in India. After all, the institution of museum had its origins in Europe and its evolution was tied to Enlightenment of the eighteenth century (Hooper-Greenhill 1999) because of its role as an institution to popularize science and knowledge. Historian Paula Findlen (1989) traced back the history to post-Renaissance sixteenth and seventeenth century Europe, where the idea of the museum found public and private patronage due to the spirit of enquiry of the age and the prestige of knowledge that came with maintaining large collections. The positivist stance that was evident in the early museum exhibitions can be found in many museums today, as museum scholars Achiam and Marandino (2013) note. However, the advent of the hands-on science centre model in the 70s ushered in a new approach towards communication. As Schiele further noted, 'Of all the changes that reoriented its priorities and redefined its practices, the most determining and significant is the factor of taking the public into account.' (p.35) In India, the transformation of the space from the traditional science museum setting of objects to that of science centres and hands-on displays was more sudden than what took place in Europe and North America. However, it was also a strategic decision taken by science policy makers and museum experts to focus strongly on public engagement for multifarious reasons: to create consensus among the public regarding the role of science and technology in the development of the state, to involve the public in the production and application of science and to reach out to far flung areas of the republic with narratives of science and technology in order to curb superstitious beliefs and aid people in cultivating scientific temper.

Public understanding/engagement/participation in science

Extant literature in science-technology-society studies (STS), and more specifically in public understanding of science (PUS), deals with the assumption that as we live in

technoscientific societies, we as citizens ought to know our rights and duties regarding science and technology as they affect our lives. (see for example, Davies and Horst 2016; Durant et al 1989; Henriksen and Froyland, 2000). However, much of the discussion in PUS directed towards science communication has used the framework provided by the 1985 Bodmer Report of the Royal Society, UK which prescribed educating the (lay) public about latest innovations; and by the 2000 House of Lords Report titled 'Science and Society' which criticized the 'deficit model' of the previous report and suggested that a two-way communication process between scientists and the public had to be developed so that the latter's voice could be heard as well. Multiple deliberations have taken place especially in the last two decades regarding the terms 'public', 'understanding', 'participation' and 'science' which have contributed further to the deficit and dialogue models. In this section, we shall examine a few of these arguments which have gained traction over the years.

Bucchi (2008) notes that public communication of science has a long history. He traces it back to the 18th century when numerous popular science books were published because of the demand for them. However, with increasing complexities resulting from advancements in scientific disciplines, the idea that science is a superior, complicated body of knowledge emerged, especially with the turn of the twentieth century and the publication of Einstein's general theory of relativity. Bucchi argues that this idea is widespread and an issue that all science popularisers, individuals and institutions, grapple with. An earlier model of communication then, which existed for the major part of the 20th century (and in fact, continues till date in parts of the world) is the diffusionist model which assumes the public to be almost a tabula rasa, or worse still, hostile to scientific information. While in the 70s, the focus shifted strongly towards communication, this almost paternalistic attitude persisted, with the so-called 'deficit' model. It is only in the last decade of 20th century and with the turn of the millennium that the question of dialogue and rendering the public with more agency and the possibility to bring in their own expertise started to gain prominence. This was complemented by the problematization or rather elaboration of the term 'public'. Increasingly, and especially in the last decade the trend has experienced a major upswing, the public has been recognized as a stakeholder, a term which has been in use in

management literature for a long time. Thus, we have science communication scholar Edna Einsiedel pointing out that: 'They are analytical constructs as much as they are rhetorical inventions. They are products of contexts: the same individual can assume different roles in different times (or at the same time)…" (pp.174-175). These roles can include members of the citizenry, users and consumers of technology or members of a group. (2008). Bandelli and Konijn (2012) define the various categories of the stakeholders (which include the public) as the following: schools, trustees, national and local governments, visitors, scientists, donors, civil society organisations, teachers, university, industry and the media. These are not water-tight categories and in fact, as I argue, the public can in fact be any individual or groups from these categories. From a peripheral role, the public has truly come a long way signaling as Bucchi (2008) indicates three distinct phases in science communication: the first which involves popularisation and corresponds with the 'deficit' model; the second which involves two-way negotiation and therefore indicates the 'dialogue' model; and finally, a more recent contemporary focus on co-production of knowledge which involves public participation in science. This third category is particularly complicated. While in museum studies literature, the seminal work of Nina Simon, *The Participatory Museum* (2010), has brought participation into the forefront, we must note that often the concept is discussed in connection with participatory exhibits and tools of participation (for example, enhanced use of IT, computer-aided design, virtual reality). In science communication, the issue of participation has also been dealt with in the context of the understanding of risks in contemporary technoscientific societies. As Horst and Irwin (2010) note, many European science policies discuss the need for public deliberation on issues like GMOs, nuclear power or animal rights. However, the question remains: is the public (at least many sections) capable of contributing meaningfully to this discussion? In a recent annual meeting of the Association of Science-Technology Centers, John Durant, the Director of the MIT Museum, shared his queries regarding whether museums and centres have managed to achieve a high degree of participation[9]. This, in my opinion, signals an ongoing debate on this issue, one to which there cannot be easy answers. In fact, the question which precedes public participation needs to be revisited: what is

[9] Association of Science-Technology Centers. (2016, September 27) Friedman science center dialogues 2016. See https://www.youtube.com/watch?v=PHj_QBkfusUv (last accessed January 2017)

scientific knowledge? Bauer (2008) writes that:

> 'Critics have argued that the essence of science is process rather than facts (Collins and Pinch 1993. Therefore topics such as theory testing, probability and uncertainty, peer review, scientific controversies, and the need to replicate experiments should be included in the assessment of literacy.' (p.117)

This interestingly brings us closer to the issue of scientific temper, a concept which encompasses the tangible and intangible, the material and the philosophical aspects of science. Bauer in fact emphasizes the need to look at Raza and colleagues' work on the importance of culture-specific indicators to gauge public understanding of science in different cultural set-ups. Thus, we could argue that from 'science and society' debates, we need to move to 'science, society and culture' discourses.

Science communication in India: the historical trajectory

In this context, it is important to note the three phases in the science-society relationship in India arising from its own cultural contexts as explained by Raza et al. (2012). The Indian science communication experts point out that the Indian trajectory in the science-technology-society relationship was different from the West as it was not rooted in Enlightenment and Industrial Revolution, but in its own colonial modernity. Modern western science had to be mastered by the subjects of British India, and the understanding that science and technology were essential to improve the condition of the population could be considered the first phase of science popularization. In terms of the period of time, this would be the mid-nineteenth century when the power of the British Empire in India was at its zenith, and English officials were radically transforming the concept of learning among natives with the introduction of British and European thoughts in the education system. In the second phase, which the authors peg around the time of the national freedom struggle (between the late 19th and mid-20th century) the idea of building strong scientific institutions gained predominance. The third phase, attained after independence in 1947, focused on the acceptance of science and technology among the public in order to build a powerful, self-reliant nation. To this analysis, I would add a fourth phase, especially considering the contemporary science, technology and innovation policy documents of the

Government of India and the activities that ensued in institutions in charge of science popularization, and more importantly as a result of the focus on the promotion of scientific temper. In this fourth phase, at least for what concerns the rhetoric of policies and institutional goal-setting, the focus is on harnessing the capabilities of India's billion plus population, especially its vast young population, to propel India's aspirations of becoming a *bonafide* knowledge-economy. As far as the language in policy documents are concerned, India has shown that it is more than capable of keeping up with the world, especially the advanced economies for what concerns the rhetoric of knowledge and innovation economies.[10] However, this is not surprising because, as Indian sociologist, Sujata Patel, an advocate of diverse sociologies (ie.,the study of diverse sociological traditions in different countries instead of heavy reliance of western theories), points out, 'we all live in one global capitalist world with a dominant form of modernity' (Patel 2010, 1). The massive global transformations ushered in by liberalization of economies have led to rapid multi-directional flows of ideas as well. The power of science, technology and innovation in a young postcolonial[11] nation, young both in terms of years of existence and the age of majority population, lies in the ability to create aspirational value for its people. This was captured in terms of actual numbers in the India Science Report of 2005, a nationally-conducted survey with a sample size of over one hundred thousand people, published by the National Council of Applied Economic Research (NCAER), which discussed public awareness of science and technology as well as participation of the population in science education and in scientific jobs, among other things. Two issues stand out from the report, and must be mentioned here as they are crucial to the arguments in the dissertation. The first is that, even with a relatively low percentage of literate people (about 64% according to the 2001 census) interest in issues of science and technology and awareness of basic science is very high.

Despite the low levels of literacy and spread of higher education, India doesn't fare

[10] See for example European Commission (2010). *Europe 2020 Flagship Initiative Innovation Union – COM (2010) 546 final*, Brussels: European Commission.

[11] Here it is important to mention that I have used this term in its temporal significance, ie, the period of decolonization that took place in large parts of Asia and Africa following the retreat of European powers after the Second World War.

> too badly vis-a-vis high-income countries like the US. India scores lower than the US on attitudes towards science and technology, but not much lower. Seventy-seven per cent of Indians feel S&T makes our lives healthier and easier as compared to 86% for the US. Sixty-one per cent feel technology makes work interesting as compared to 89% for the US. (Shukla 2005, 51)

A second, even more telling data, is the percentage of students who want to pursue sciences, engineering and medicine, especially those who are still in the middle school, with about 60% students indicating that they would want to pursue a career in STEM (acronym for science, technology, engineering and medicine). This percentage is sustained all through the school career with about 57% in high school indicating the same. About 40% of all middle school students said that they would want to become 'an engineer or a doctor'. (Shukla 2005, 16), thereby indicating the perceived importance of science in the society. The number of students aspiring for a STEM career however dropped significantly in the rural areas, and this is where the question of reaping demographic dividends of India's vast young population becomes extremely challenging. The uneven nature of Indian society in the throes of contemporary capitalist modernity is well articulated by Patel in the following words:

> Inequalities and hierarchies are being differently organized even though we all live in one global capitalist world with a dominant form of modernity. Lack of access to livelihoods, infrastructure and political citizenship now blends with exclusions relating to cultural and group identity in distinct spatial locations. This process is and has challenged the constitution of the agency of actors and groups of actors. (Patel 2010, 1)

The task then, to uplift large sections of the population into self-reliance and self-sustenance, is a gargantuan one: one that needs robust policies and an even more emphatic operationalization, through various public institutions and organisations in charge of managing civil society. This is where, I argue, lies the importance of the National Council of Science Museums, both as a public institution and as an organization of national importance in charge of communicating and popularizing science, as well as promoting the

notion of scientific temper among members of the society. A 1992 deliberation made by Saroj Ghose at an ICOM meeting with leading museum professionals from around the world is particularly illuminating for understanding the role of museums in developing postcolonial states. In his discussion, he pointed out that many of the states that came into existence in Asia and Africa after the Second World War had to focus on social, economic and scientific developments and it would seem as if museums and arts were low on their priority list. However, in reality, museums in the post-colonial states became spaces for asserting new independent identities. And therefore, even though developing contemporary interactive museum exhibits is expensive and the new independent nations have their focus firmly on building infrastructure, museums have continued to receive state patronage because of their role in defining national identities.

The role of museums is considered essential in the nation-building process of post-colonial states. Museums have long been accorded prominent position in civil society due to their ability to engage public with multiple issues (Bennett, 2005; Welsh, 2005; Achiam and Marandino, 2014). Governments have recognized the importance of museums as the node that connects multiple stakeholders, as explained by Achiam and Marandino (2014) when they cite a Danish Ministry declaration, 'The [science] centre must serve as a channel of communication between citizens, educational institutions and research institutions and should accordingly disseminate research results that are relevant to its content area (Danish Ministry of Education, 2000).' Similar aims and objectives have also been prescribed by the Norwegian Ministry of Culture which discusses the importance of the museum as a dialogic space (Henriksen and Froyland, 2000). In the recent years, however, in Western countries, according to museum management literature, public funding has been reducing drastically. Museums are now required to prove that they are worthy of public support. (Scott, 2011). Is this the case with the NCSM as well? Or does the Ministry of Culture, Government of India, which is the main funding body of the NCSM consider its role in science popularization, communication and education to be that of a public service provider? The answers to these are intrinsically tied to the question: What is the role of post-independent science museums in contemporary Indian society? The follow-up queries would then be: How is the role influenced by science policies, given that the museums are publicly funded? Is there a certain public culture (narrative) of science that is promoted in

the Indian science museum(s)? This dissertation is an exploratory work in which I will be examining these broad questions closely. They warrant the use of multiple interdisciplinary lenses and approaches, as described in the following section.

The question of method(s)

While India has received some academic attention separately in the fields of science communication, public understanding of science and museum studies, the issue of science communication in Indian museums has remained relatively unexplored. Yet another consideration that played a major role in the selection of India has been the need to theorise local Asian experiences to provide alternative viewpoints to the development of STS narratives in non-Western settings (Chen, 2012). My dissertation aims to bridge this gap in knowledge and to do so it employs a multiplicity of methods and approaches. Here, I first reconstructed the history of the science museum movement in India and examined the role of NCSM in it. For this part, in-house publications of NCSM along with government policy documents (which are available online) have been used. Such publications include, annual activity reports, special volumes commemorating significant milestones, monographs and articles written by NCSM professionals, mission statements, organization charts, brochures of galleries and the official website. Second, I employed an ethnographic approach for further data collection to provide a more comprehensive picture of the contemporary history of NCSM, its policies and activities. For this purpose, I carried out four in-depth interviews (each of about an hour) with highly involved stakeholders from the NCSM management. To probe more in-depth how the constituent museums of NCSM function, I selected the Birla Industrial and Technological Museum (BITM), Kolkata, which is the first public science museum in India and one of the national-level museums under NCSM. At the BITM, I carried out five more interviews of varied duration (ranging between thirty minutes and two hours) with the director, education officer, curator of one of the engagement facilities called ‘Innovation Hub’ and two explainers. While the NCSM headquarters and the BITM (both located in Kolkata where I conducted my fieldwork for three months between June and September 2015) are the main case studies analysed here, I also carried out two more interviews with the director of Science City, Kolkata and a

senior curator of the Visveswaraya Industrial and Technological Museum (VITM), Bengaluru; both institutions are under NCSM as well. These two interviews were carried out to gain a broader perspective on: a. the various types of institutions under the aegis of NCSM (Science City is a combination of a centre, museum and science park) and b. the diversity of topics covered by different units under NCSM (as in the case of VITM). Inputs from these two interviews have informed the general understanding of the role of NCSM in the country. All interviews were based on semi-structured questions and were carried out in person. Some of them have been carried in the Appendix, after receiving the permission of the interviewees. Apart from the interviews, I visited all the galleries of the BITM and took notes on their content. To achieve better understanding of the engagement activities at the BITM, I attended one of the sessions of the 'Innovation Hub' as a participant observer. Furthermore, I received data on a visitor survey carried out in-house at BITM, which I then coded using STATA. The results of the survey have been discussed in the third chapter.

In addition to the fieldwork carried out in Kolkata, I spent two periods of one month each in Milan at the Museo della Scienza e della Tecnologia and the Smithsonian, Washington DC. The former was chosen to study contemporary communication strategies employed by European national science museums, the early benchmark of BITM. The latter was selected primarily because of its long history of collaboration with NCSM. At the Smithsonian, I carried out four more in-depth interviews (of about an hour each) with professionals who were actively involved in the collaboration with NCSM. Further data was collected at the Smithsonian Archives which has preserved documents of interactions between previous employees of both institutions. In STS, multi-sited ethnography is increasingly being adopted by researchers (Hine, 2007) with the recognition of the fact that contemporary society is increasingly becoming more connected (Urry, 2000). My work makes use of this approach in order to understand the role of foreign institutions in the making of NCSM and their contribution to the culture of science in India, as well as the place of NCSM in global discussions on the role of science museums and centres in the society.

After carrying out content analysis of the public policy documents, ethnographic data and the primary literature created by the museums, I arrived at certain recurring and connected

themes which have been discussed in the four chapters. Here it must be clarified that while in the introduction, I have provided an outline of literature review and methods, each chapter carries a discussion on the disciplinary and methodological concerns specific to it. The first chapter introduces museums in India, providing a brief history of the institution beginning with its colonial origin. It continues with a discussion on public perceptions of museums in India, analysing the results of an online survey with about 90 responses. It also introduces some arguments regarding the history of NCSM (thereby connecting it to the second chapter) and show why the NCSM deserves to be studied especially for its role in science communication, public participation and education in the Indian context. In the second chapter, the Council will be examined in depth as a national institution which draws public money for its management and activities, and positions itself as one of the leading science communication institutions in the country. The goals, objectives, structure and functions will be explained stressing the fact that this centrally managed organization with a number of subsidiary units spread across the vast territory has few parallels around the world. Special focus will also be on the history of the science museum movement in India and NCSM's role in it. The proliferation of the science centre model of communication will be explained in conjunction with a reflection on global trends which affected the science museum space. In the third chapter, one of the main national units of the NCSM, the Birla Industrial and Technological Museum in Kolkata will be taken up as a case study to understand the various activities of the NCSM. Existing literature on science communication and education practices will be considered alongside data collected at the site to understand how the NCSM (and BITM) speaks to its public. The BITM itself will be studied thoroughly, including its exhibits, activities and special programmes. This analysis will give the readers a clear understanding of what constitutes the idea of science in this museum. In this context, the concept of scientific temper and its role in Indian democracy as well as its inclusion as one of the primary goals of NCSM will be discussed again. Finally, the fourth chapter will look at the emerging narratives of local and national cultures and histories of science, technology and society in science museums and centres. Attention will also be paid to bring together examples from other parts of the world to comment on varied narrations in different parts of the world. Secondary literature from heritage studies and history of science will be used to understand how heritage and history

can be used and have been used as powerful anchors to narrate stories of science and technology. The chapter will also discuss the national narrative of the promotion of scientific temper that emerges from the NCSM's activities.

Chapter 1. Museums in India: from colonial to contemporary

The problems and questions of understanding and representing science have long been addressed by many fields of study in humanities and social sciences which developed over the course of the twentieth century: history of science, public understanding/participation of science, science communication, sociology of scientific knowledge, study of science museums and collections, and of industrial and scientific heritage, to name some of the major interdisciplinary and multidisciplinary areas of research. My own research aims to bring together some of these fields, as I attempt to understand how discourses of scientific knowledge are constructed in museums in different regions of the world, with special focus on providing an appraisal of the Indian museums. For this purpose, I have carried out an in-depth study of the research articles of Indian historians of science, among them Dhruv Raina, Deepak Kumar, Kapil Raj; of science museum specialists like Saroj Ghose. My attempt here is to bring together ideas about creation and proliferation of scientific knowledge in the Indian context as discussed by academics and professionals; and examine if and how Indian museums are representing these ideas. As there is very little research output on these issues, and especially because the subject of science communication in Indian museums has received very little academic attention from scholars of science and technology studies, my work involved a period of empirical research in India, where I interviewed museum officials to collect data. In this dissertation, I will present perspectives on science communication from the point of view of museum professionals and specifically the management of the museums. In the recent years, the need for a dialogue between scientists and the public, as well as the difference in the quantum of research outputs on science in the West vis-à-vis science in the East—has been emphasized greatly, specifically for the framing and revising scientific histories and narratives[12]. From my readings and field visits, what has become evident is the need for a meaningful investigation into how

[12] For example, in most of the recent conferences and meetings of academic societies (which I participated in) like Society for the Social Studies of Science and European Society of History of Science and in Science and Technology Studies Italia, the invited speakers in the plenary sessions stressed this need for dialogue between East and West.

science has been localized and universalized. To achieve this aim, the study of institutions which communicate science to the public becomes an absolute necessity.

This chapter is an effort to understand one such institutional category: science museums in India. The different parts include, a brief discussion on the academic output on state of museums in India followed by the results of a survey on how museums are perceived as an institution by Indian citizens; an outline of the various channels of distribution of scientific information with a focus on the apex body of science museums in India, the National Council of Science Museums (NCSM hereon); and, the case of railway museum in New Delhi (which unlike most museums under the NCSM, is a history of technology museum with a large collection of historically significant artefacts)—the historical narrative it communicates and an appraisal of how it does so. With these three parts, my attempt is to provide an understanding of what 'museum' means to Indian people, both the public and the institutional employees (the chapter makes use of personal interviews carried out with museum professionals), especially what is a science museum in the Indian context. The intention is to understand the category and to look at some of the varieties that are present in the country. One important point that needs to be emphasized at this stage is that the chapter does not attempt to provide an overall picture of how scientific knowledge and narrative is constructed in Indian museums. However, it does ask preliminary questions related to the kind of science that is on display, as well as comment upon the history of science and technology of the country that emerges from these artifacts, exhibits and installations.

1.1.Science and its institutional channels of distribution

Dhruv Raina, Professor of history of science and education at New Delhi's Jawaharlal Nehru University, writes that the story of India's emergence as the emerging scientific and technological power of the world cannot be studied only by looking at the elite institutions of research of computer science and information technology (Raina 2011b). In accordance with Raina's comment, my proposal is therefore to consider the various institutional channels of distribution of scientific communication (public institutions to facilitate the

emergence of a picture of public understanding of science in India), as well as to create a scientific identity which is unique to the country. These channels of distribution include, but are not limited to: educational institutions, science academies, libraries, museums, archives, print and television media. The Internet and its vast repository of online archives should be considered separately as it provides and combines virtual versions of all the aforementioned channels. Furthermore, Raina pleads for a greater engagement with science not just at the level of research institutes, which there are many in the country, but also at other institutions. What however is required is an intensive and extensive public discourse on science and its history, more specifically the history of knowledge transfer that took place in the colonial times and even before[13].

There are multiple centralized public institutions in India which concern themselves with the task of studying the interactions between science, technology and society; communicating science and technology and also recording narratives of science for social and historical purposes. The National Institute of Science, Technology and Development Studies (NISTADS), New Delhi is a central think tank attached to the Council of Scientific and Industrial Research (CSIR), Government of India, whose mandate is to provide policy advocacy on techno-socio-economic issues identified by CSIR.[14] Yet another research institute under the CSIR is National Institute of Science Communication and Information Resources (NISCAIR) which is dedicated to bringing scientific information to the citizens, especially the youth and also to act as a linking node between various scientific

[13]Indrajit Ray, librarian at the Central Silk Research Institute in Berhampore, India, in a personal interview expressed regret over the lack of interest in recording local histories related to the production of silk. He talked about technologies which were in use for the various stages of production in and around the region of Murshidabad, one of the most important places for silk production in India for centuries, and how there remain no records of indigenous processes of reeling of silk.

[14] See the website of the National Institute of Science, Technology and Developmental Studies, especially the introduction page, http://www.nistads.res.in/index.php/about-us/introduction (last accessed January 2017)

communities by publishing research journals on various areas of science and technology.[15] The institute publishes several magazines on science popularization as well as the *Journal of Scientific Temper*, which carries articles on public understanding of science.[16] Vigyan Prasar (the name roughly translates to 'science proliferation') is yet another organization active in science popularization and in promoting a scientific/rational outlook. It is an autonomous body under the Department of Science and Technology (DST), Government of India[17]. Then, there are other institutions, also private, which concern themselves with the history of science and technology in India like the Tata Institute of Fundamental Research (TIFR) in Mumbai which maintains an archive of oral narratives of scientists[18] and the Indian National Science Academy which has been publishing the *Indian Journal of the History of Science* since 1966.[19] Among this mix of institutions with diverse but related aims and objectives, we find the NCSM which, operating under the aegis of the Ministry of Culture, Government of India, is concerned with communicating science to the multifarious sections of the Indian society and to engage them, in varies degrees, with the uses and applications of science and technology in society.

[15] See details on multiple popular science publications of the NISCAIR on http://www.niscair.res.in/ScienceCommunication/sci.asp?a=topframe.htm&b=leftcon.asp&c=Root/Scicommun.htm&d=test9 (last accessed January 2017)

[16] The phrase 'scientific temper' is central to the science communication and public understanding of science debates in India. A term coined by independent India's first Prime Minister, Jawaharlal Nehru, it encompasses the aspiration of the newly independent nation to base its ideals on rational thinking. The term has become a catchphrase for public institutions in India which deal with research and promotion of science and technology. In the subsequent chapters, the phrase will be discussed extensively in conjunction with the activities of the NCSM.

[17] Annual report of Vigyan Prasar can be accessed here: http://www.vigyanprasar.gov.in/annualreport/Annual%20Report%202015-2016/annual-report-2015-2016-english.pdf (last accessed February 2017)

[18] See http://www.tifr.res.in/~archives/oral_history.php (last accessed January 2017). The webpage tells us that an oral history project is ongoing at the Tata Institute of Fundamental Research, Mumbai, which involves documentation of multiple-session interviews with 41 TIFR scientists and administrators.

[19] See http://insa.nic.in/UI/journaldetails.aspx?AID=Mw== for a short discussion on the history of the Indian National Science Academy and their publication, *Indian Journal of History of Science*. (last accessed January 2017)

The need for the 'participatory turn' of non-experts in public discourse of science has been recognized by major STS scholars in the last decade including Jasanoff (2003), Kleinman (2000), Nowotny, Scott and Gibbons (2003) and Lengweiler (2008). In museum studies, participation has been discussed in conjunction with interactive exhibits, social interactions or even participation of the public in co-curating and decision-making processes of science museums and centres. (see Bandelli et al 2009, Heath and vom Lehn 2009, Simon 2010). In the 'public understanding of science' literature of Great Britain, what is evident are three key phases in the way the relationship between science and the public has been constructed: scientific literacy, public understanding of science, and science-in-society[20] (Bauer 2009). Bauer, one of the major scholars contributing to this multidisciplinary approach of public understanding of science, furthermore observes, that these phases are not about development of discourses but multiplicity of them. Since my topic of investigation is museums, it would be interesting to see which of these strategies is more in use in the way Indian museums communicate with their visitors. Or is there a unique Indian model of science communication which combines multiple strategies and brings in something new? This question will be discussed at various lengths throughout the dissertation, culminating in a definitive response in the final chapter.

The choice of museums for the study was directed by my interest in creating a dialogue between STS, museum studies, and to a certain extent, the history of scientific institutions. Museums as scientific institutions provide the vital ground/link for recording, preserving and sharing of historical objects and practices in the most engaging ways. And yet, very little academic attention has been given to the study of museums in India, and even less on science museums. This chapter, and indeed the dissertation is therefore an initial attempt at discussing this topic. Interest in the activities of science museums and centres has grown over the years around the world, especially in relationship with UNESCO's goals of

[20] In the subsequent chapters, I will be discussing the various models of science communication that have come up over the years, namely, the deficit and dialogue models. The former suggests that the lay public has to be taught certain aspects of science and technology pertaining to their daily lives, while the latter acknowledges that members of the public have their own inputs which can enrich dialogue with scientists. At present, science communication scholars have concerned themselves with the task of finding methods which go beyond deficit and dialogue. (see for example, Davies and Horst 2016)

sustainable development and 2016 also marked the celebration of the first International Science Center and Museum Day on the 10th of November[21]. This dissertation, therefore, is written with the understanding that it is an opportune moment in the history of science museums and centres around the world to create local and global understanding of the science's role in shaping the society and the society's role in defining science and technology.

1.2. Locating the Indian museum as an institution historically

It is in the 19th century that the first museum was set up in India. In fact, the very first one was aptly called 'Indian Museum' and was established in Calcutta, which was the centre of British power in India, in the year 1814. The museum was created under the patronage of the Asiatic Society, an institution formed by British scholars interested in study and research of the East, or Orientalists as they were called. The history of the early establishment of the institution in a non-European setting deserves further critical thinking than what the dissertation has offered, as the focus has been on contemporary (read post-independent) museums and centres of science in India. Interestingly till today, it is considered to have one of the largest collections of artifacts among museums in India, and thus it enjoys patronage of the Ministry of Culture, Government of India[22]. As the museum's website states: "Founded in 1814 at the cradle of the Asiatic Society of Bengal (at the present building of the Asiatic Society, 1 Park Street, Kolkata), Indian Museum is the earliest and the largest multipurpose Museum not only in the Indian subcontinent but also in the Asia-Pacific region of the world." The six sections of the museum include galleries on archaeology, art, anthropology, geology, botany and zoology. However, due to the general state of apathy towards museums[23] and related activities in the country, even

[21] The website of the International Science Center and Science Museum Day is available here: http://www.iscsmd.org/ (last accessed December 2016)

[22] See the official website of the Indian Museum for further information on the history, exhibitions and galleries: http://indianmuseumkolkata.org/ (last accessed January 2017)

[23] It must be clarified here that the NCSM and its constituent museums cannot be considered under the same rubric of Indian museums. The NCSM's management stressed this multiple times in the personal interviews I carried out during my India visit. In fact, often NCSM officials are asked to provide

this venerable institution has suffered massive decay when it comes to the basic structure of the building. Its invaluable collection on the ancient Indus Valley Civilisation was inaccessible to the public for over ten years, including a large part of the previous decade of the 2000s[24]. But the decaying façade and the lack of access to one of its prized collections are not the only problems with the Indian Museum. The museum in the recent years have been mired in controversies, starting with the instability at the very top. In the last five years, it has had three directors.[25] One of them was even forced to quit because of disappearance of the conservation officer of the museum.

A report in *The Times of India*, a leading English-language news daily, mentioned a few years back: 'The Indian Museum, the oldest in Asia-Pacific region, is caught in a time warp, clinging to ideas that have ceased to be relevant. The Centre, board of trustees, management, staff are aware of the shortcomings, but only a handful is willing to change the system.'[26] The museum officials understand, as the article goes on to explain, that finding new ways of exhibiting the displays is an absolute necessity. They are thus trying to incorporate elements like live exhibitions, cultural shows in appreciation of heritage to attract more visitors. The fact that one of the recent recruits was trained at the British Museum and the Smithsonian Institution reflects that they are seriously considering a major revamp so that the museum can match up to international standards. Renovation work of the galleries has been outsourced to competent British architects. As Anup Matilal, then acting Director of the museum said in yet another news report carried in the same newspaper "Of 36 galleries, 16 to 18 will be renovated by February 2014 for the museum's

infrastructural and institutional support to other museums of national and international importance because of their years of training and expertise in the field. They also develop exhibits and galleries for other museums.

[24] The article describing the mismanagement at the Indian Museum is available online at http://timesofindia.indiatimes.com/city/kolkata/Harappa-gallery-locked-for-10-years/articleshow/11969640.cms (last accessed December 2016)

[25] The primary source for this information was a newspaper article available at http://indianexpress.com/article/cities/kolkata/controversial-indian-museum-director-quits/ (last accessed January, 2017).

[26] A 2012 newspaper article that provided information on the renovation plans can be accessed here: http://timesofindia.indiatimes.com/city/bengaluru/Indian-Museum-In-the-throes-of-change/articleshow/17605202.cms (last accessed December 2016)

bicentenary. The eight galleries on science will be done up by National Council of Science Museums while archaeology, anthropology, painting, pre-history galleries will be done by UK-based architects Chapman & Tailor." It is of course important to note the involvement of NCSM with all kinds of museum-related activities in India. Not only is the mandate of NCSM to communicate science among India's population, but also to provide infrastructural support to other existing museums in the country.

However, this brings us to another crucial point. If the recruits are trained abroad and work is also outsourced to countries with stronger traditions of museums, what is the situation of training of museum professionals in India? Bedekar (1987) writes that the need for museum training was recognized early on in India, as early as in 1907. Especially in the Second India Museums Conference in 1912 the need for trained curators and better management of museums was discussed. The Museums Association was formed in 1944, but the problem lay with the fact that it did not have a dedicated physical space and did not lead to much credible efforts on the part of the Association members. The NCSM has taken significant steps in this regard to ensure a continuous flow of well-qualified professionals by introducing a Master's level course in science communication for training aspirants (jointly with Birla Institute of Technology and Science, Pilani, one of the more well-regarded institutions of technical education), which is taught by NCSM employees as well as other professionals from benchmark museums such as the Smithsonian.[27]

1.2.1. Scholarly perceptions of the institution of museum in India

> Indian museums, like ninety per cent of the museums in the world, are principally storehouses of antiquities and oddities of nature, and the "museum" as it is perceived in reality by the general public throughout the world is a dingy structure containing dingy objects that are piled on top of one another much as in an attic or storage cellar. Of all the sources of public education in the world today, the museum

[27] The collaboration with Smithsonian employees will be taken up in the second chapter.

> is probably the most neglected and the least supported, and its full potential is the least appreciated or realized. (Witteborg, 1960)[28]

Witteborg, then Chief of Exhibition at the American Museum of Natural History, wrote about public perception of museums as a general comment about visitors around the world. This image seems to have sustained in the Indian imagination to the present day, if we go by the findings from the survey (which I will discuss in a subsequent section), even though much have changed by way of incorporating interactivity in exhibits, pioneered by the designers at the NCSM. There is another crucial point Witteborg makes, that about the role of museums in public education and how it has not gotten enough attention. He poses a very interesting question in the first part of the paper:

> Does India, with a population of four hundred million people, want its masses to visit its museums for general educational enlightenment, or does the government want to retain its great repositories for the exclusive use of research scholars and sophisticated gentry?[29]

The Indian population since 1960 has more than tripled, but the function of the museum as a repository for researchers and 'sophisticated gentry' has not changed much. In fact, that is the precise area where, I argue, drastic change is required. The museums need to redefine their audience in keeping with their role as a viable educational institution. I have not yet come across any academic article which discusses the percentage of Indian school children visiting museums, but that is where museums could do well in researching and enlarging their potential visitors' pool. There is yet another reason why museums have not historically reached out much to schools and the aforementioned article has a quote which explains it well:

> [M]useums in India are largely under the direct control of the central government or state governments, who have chosen scholars rather than educators as administrators for these institutions. Furthermore, it is significant that the Ministry

[28]Witteborg, Lothar P. 1960.'The Situation of Museums in India'. *Curator: The Museum Journal.* Volume 3, Issue 1, pages 66–74.
[29] ibid

of Scientific Research and Cultural Affairs, rather than the Ministry of Education, has charge of the administration of museums.[30]

This Ministry of Culture operates separately from Scientific Research but still its ties with the Ministry of Human Resource Development (which is in charge of education) are very few. Museums are still neglected vastly in school curricula. However, this is only one of the many problems discussed in Witteborg's paper. The others have been listed below. These were the writer's observations about the physical structure and displays in the museums in 1960.

- Crowding of the museum scape with objects.
- The visitor left to his/her own means to decipher the material.
- Careless attitude towards the maintenance of precious artifacts, not knowing the value of the displayed items
- No attention to displays. The illumination inside the museums during daytime is often possible due to sunlight entering through the large windows which in turn is harmful for the artifacts. During overcast days, they resort to low wattage bulbs which hardly help illuminating the large number of artifacts on display.
- Museum structures which have become outdated as the design of the buildings is often in the neo-Victorian style. Large windows (as mentioned earlier) are a part of that style which is problematic for the health of the artifacts. Furthermore, there is not adequate space for exhibitions, for storage and for office work.

A number of these criticisms regarding unwieldy structures of museums are addressed by the Director of the Government Museum in Madras (now Chennai) in a 1966 article in *Curator: the Museum Journal*[31]. Mr Satyamurti accepted the wide gap in aesthetic displays between Indian museums and those in Europe and North America. He acknowledged the fact that government funding had been rather poor which was the reason behind existing

[30] ibid

[31]Satyamurti, ST. (1966). Modernization of the Madras Museum. *Curator: The Museum Journal* 9(1):67-84.

structures not being upgraded. However, changes started coming in slowly, with galleries getting makeovers, for example in terms of displays which were not cluttered and not in slanting glass boxes but in vertical ones. However, evidently, the changes required for these institutions to function as effective repositories and communicators of knowledge are manifold and more substantial than the display arrangements.

Almost fifty years later, Jyotindra Jain (2011) writes that for a country of temples, it was a natural choice for Indian museum professionals to accord such a venerable status to the museum. He also argues that unlike many other colonial imports, like railways and the game of cricket, the museum was not adapted to approach and engage the masses. We will see, in the next section, if Jain's view still holds today. However, this is also the precise point of departure for the Indian science museum professionals who proposed the science centre as the optimal model of communication of science and technology for mass education and lifelong learning. As Duncan Cameron wrote in 1972, the museum could be perceived as a temple or as a forum (Bandelli et al, 2009; Jain, 2011). In the discussions that will be carried in the subsequent chapters, it will become clear as to why and how the Indian science museum professionals chose the 'museum as forum' as the preferred model for communicating science to the public.

1.3 Public opinion on Indian museums: a short survey

The following section is based on a survey that I carried out using the free online survey tool 'Surveymonkey'[32] which I shared with potential respondents in certain specific periods: between July and August 2013, April 2015 and July 2016, which garnered a total of 86 responses from individuals, all Indian citizens, of ages between 20 to around 50, fluent in English, with one or more university degrees, adept in using social media (as the survey was posted on Facebook and was shared through emails.) This demographic description is by no means an accurate representation of the vast Indian population. Such an exercise was carried out only to get a preliminary sampling of how a segment of highly

[32] See http://libguides.ioe.ac.uk/c.php?g=482417&p=3299152 for an understanding of how the online tool can be used.

educated potential visitors perceive the museum as an institution in India, because there is little to no academic work on this issue.

1.3.1 The questions and the analysis

I shall list below the questions that were in the survey, which were aimed at gaining an overall understanding of how people perceive the museum as an institution. The idea behind carrying out this survey was also to identify some of the crucial issues related to Indian museums that (potential) visitors perceive to be important. The choices were pre-determined with respondents choosing between one (or at times, more than one) of four options. Space was also provided to comment more in-depth for some of the more qualitative questions. The questions are listed below.

1. How many museums do you visit in a year?
2. What is the type of museum that you are most likely to visit?
3. What is the main reason for you behind visiting a museum?
4. What is your opinion on entry fees to public museums in India?
5. What is the type of ownership of most museums in India?
6. What is your opinion about museum management in the country?
7. Which among the following is the most significant improvement that you would like to see in Indian museums: more informed staff, better displays, greater volume of artifacts, better websites, improved use of information and communication technologies, better engagement with visitors, more focus on tourists? Rank them in order of importance.
8. If you want to find information regarding a museum, are you most likely to do a Google search, visit the website of the museum, ask friends or relatives, or more likely to find information in travel brochures?
9. What would you say is the most significant difference between museums in India and the west?
10. Which of the following statements would best describe your perception about Indian museums and their place in Indian heritage?

Questions 1 and 2 were framed to gauge the level of interest on the part of the visitors. The majority of respondents, nearly 57%, chose option 'a' for the first question, which was 0-1. And another 25% said that they visit about two museums in a year. Thus, an overwhelming number of respondents, which is representative of the middle-class urban academic elite (82%) visit two or less museums and some even none. Furthermore, when asked about the type of museum they are most likely to visit, 51% selected the general 'multipurpose'[33] museums, in the likes of National Museum in New Delhi and Indian Museum in Kolkata. However, the rest of the 49% were divided in their interests with more or less equal number of people preferring to visit traditional arts and crafts museums, science and technology museums and those exhibiting contemporary visual arts. It was interesting to note that the 'multipurpose' type is largely the one which is readily identified with the term 'museum'. Secondly, going by the responses it can be argued that the footfall in Indian museums definitely needs improvement, especially when the social group who is most likely to visit them is staying away.

The third question about the motivation to visit museums yielded varied responses. The four options were: for educational purposes, for infotainment (a neologism which means information plus entertainment), to spend a day off in a good way and to get to know the culture of a place better. There was no clear majority for this one, even though 36% selected infotainment, followed by 26% selecting education as their main motivation. Another 27% selected the final option, of getting to know the culture of a place better. It is evident that while the sample of Indian public in the survey believes that museums have great educational values, they are definitely not only looking for this value upon a visit to a museum. There must be more than dissemination of information; there has to be an entertaining way of doing so. The 12% who selected that it is a good way of spending a day off could then also grow in numbers, thereby increasing greater footfalls.

[33] The phrase 'multipurpose museum' has been used in this context as a catch-all term to define the type of museum which has collections encompassing many areas of human knowledge, including and not limited to, archaeology, natural history, science and technology, arts and crafts. The 'storehouse' museum is an institution which works as a storehouse of antiquities, which is what the first museum in India, the Indian Museum, was designed to be.

The fourth, fifth and sixth questions can be looked at together because the perceptions about them go hand in hand, especially in the Indian society. The question about the entry fees in public museums resulted in the majority stating that they were too low (almost 56%) and another 40% saying that they are moderately priced. This is an interesting revelation given that the respondents visit very few museums in a year, if at all, even though they recognize their value. Some possible reasons will be explored in the analysis of the final questions of the survey. The fifth question about the ownership of majority of museums in India showed that the people are aware that most of the museums in India are public, with 72% saying so. This of course does not take into account the fact that a number of private collections also function as museums, as well as heritage buildings which have been turned into private hotels are not viewed by the general populace as museums either. There was an overwhelming majority in case of one of the options for the sixth question which was that the management of museums in India had to drastically change. 73% selected that option. While framing the questions in the survey my expectation was that a large number of respondents will select this option given that in public opinion the state of affairs in museums in India cuts a rather sorry figure.

The final three questions tried to delve deep into the various problems which could be attributed largely to mismanagement. The seventh question was about what needs to change in museums and respondents had to rank the options in the order of descending importance. The most common first choice was 'more informed staff', followed by 'better displays' and 'better engagement with visitors'. These three were also the top three second choices clearly suggesting that people felt that these were the crucial areas where drastic improvement was required. Here it is important to recall the previous section where I had discussed how the problem in many museums in India is the fact that the staff are not trained to deal specifically with the requirements of the museum as a unique space for the dissemination of knowledge[34]. What was interesting for me was that 'improved use of

[34] In case of NCSM, the organization hires from a talent pool that it develops during the course of the Master's programme in science communication. The programme is one of the many activities that the NCSM has developed, and as such, could be considered a kind of outreach programme to greater participation of citizens in science communication activities. The entry requirement to this course of study is a Bachelor's degree in the technical or natural sciences. Once accepted, students are trained by professionals from India and abroad (staff from the Smithsonian have taught students over the last two

information and communication technologies' and 'better websites' figured as a third choice for about 17% and 14% of the respondents respectively and 'more focus on tourists' (tourist here implies both domestic and foreign) was not really considered a priority by most, with 58% voting it as the final issue to be addressed. This clearly shows that the respondents feel that there has to be a number of internal changes first in the museums before they look into better strategies for marketing themselves. Furthermore, it could also imply that Indian people do not consider themselves as tourists in their own museums, so they are looking forward to a greater focus on them as visitors so that the displays can be engaging for them.

For the eighth question, 78% people said that they were most likely to do a Google search to find out information about a museum. This is where I think museums in India really need to step in and improve their websites with better information, virtual tours, interactive applications et cetera so that people get all that they require from the officials themselves. India with its large young population will surely have no dearth of skilled individuals for this upgrade.

The question about the differences between museums in India and the west had the possibility of multiple answers. The top three in this case were better use of technology, better management, and greater interest on the part of the visitors. Clearly the respondents think that the volume of artifacts in India is enough because very few respondents thought paucity of artifacts was an issue. But it is how the artifacts are displayed, how the audience is engaged with them, and how responsive the audience is. The lackadaisical attitude is thus not only on the part of the museum authorities but also the visitors in the Indian scenario.

The final question tried to tap into the general sentiment of people about the museum as an institution. It asked respondents what they thought was the museum's place in Indian heritage. About 42% of respondents chose the option 'I know that they are important, but somehow their need is not perceived strongly in our socio-cultural sphere'. 26% of

decades). The collaboration between Smithsonian and NCSM will be further dealt with in the subsequent chapters.

respondents thought that they are integral to the public domain and another 26% felt that no one really talks about museums in India. With this question, it was possible for respondents to comment further on the issue and one of them wrote: 'I know that they are important, but the organisation itself remains passive to the socio-cultural context'. This sentence sums up the opinion of a large number of respondents of this public survey. It was thus important for me to try to engage with the NCSM and examine how they address their own role as a public institution, and what they do to engage their potential visitors.[35]

1.3.What is a science museum in India?

In the introduction to an article on the history of science museums in India, Jayanta Sthanapati, a science museum professional who served as a director of the Birla Industrial and Technological Museum (BITM), Kolkata, writes that in 19th century British India "no modern science museum fully dedicated for display of science and technology was established." (Sthanapati 2013, 19). Exhibits on natural history were available with the establishment of two museums, namely Bombay Natural History Society Museum (1883) and Bengal Natural History Museum, Darjeeling (1903). A collection of artefacts was present at the Lord Reay Industrial Museum in Pune, established in 1875. (Sthanapati, 2013) However, it was only after India's independence that multipurpose science museums and planetariums were set up. There are many different kinds of scientific institutions which come under the ambit of science museums, as described by S Kumar, director of the NCSM headquarters. In a personal interview, he suggested that apart from all the centres developed by NCSM,

> There are science centres and technology museums under the control of state governments and private institutions such as Birla Museum, Pilani. A number of universities also have collections of science as can be seen in the case of the Birla Museum of Pilani. Zoos and Planetaria also come under the definition of non-formal science education centres. Then there are multiple important museums with extensive collections in their natural history sections, like the Indian Museum in

[35] For future research, it would be interesting to carry out similar surveys with NCSM visitors from various social-economic backgrounds and see if and how the responses differ.

Kolkata which houses archaeological artefacts. There are also special museums like the Railways and Toilet Museums in Delhi which are focused on a specific topic. One can also include institutional museums like the State Bank Museum (of the most important public bank in India, State Bank of India) in this list.

It is important to discuss the name 'science museum' which is attributed to an(y) institution in India. Firstly, does science encompass technology, or to put it in another way, is it necessary to make the distinction to reach an understanding of the nature of the subjects the museum is dealing with? Secondly, do we also talk about science centres when we talk about museums? The apex body of science museums in India, the National Council of Science Museums, which operates under the aegis of the Ministry of Culture, Government of India, uses the terms interchangeably in the homepage of their website. While literature on science museums clearly makes a distinction between the two (science centres focus more on a hands-on approach to communication), NCSM chooses to do otherwise[36]. Here it may also be worth asking the question: is it necessary for the organisation to make a distinction between these two terms? Its purpose is science education for the masses who understand the term 'museum' as a place where one goes for both education and fun (edutainment). If the purpose of NCSM is to attract visitors, then the use of the word 'museum', I argue, is crucial to retain its image as visitors can understand such a time-tested category better. The question of science and/or technology is perhaps more difficult to answer. Saroj Ghose, an eminent museum professional and a former director at the NCSM, problematises their relationship further in a historiographic account of critical works on this issue in an article from 2007[37]. That technology is applied science with industrial uses has long been argued by historians of technology and this means-end

[36] The distinction between science museums (as institutions with collections) and centres (spaces with hands-on exhibits) was drawn by Durant (1992). However, in recent years, the differences have been reducing. One of the officials from the Association of Science and Technology Centers (ASTC), Washington DC, in a personal interview, mentioned the same explaining that the gap between the two institutions in terms of exhibits and activities is closing in. Museums are embracing hands-on exhibits to attract and educate, while science centres are increasingly looking to contextualize their displays.

[37] Ghose, Saroj (2007). Technology: What is it? In J Dasgupta (Ed.) *Science, Technology, Imperialism and War*. New Delhi: Pearson Longman

relationship can be problematised, but from Ghose's article one other notion becomes prominent, that of technology developing independently from science. He also argues that it is only around the mid-nineteenth century that science and technology started getting into a means-end relationship. From my own visits to three of the science centres governed by NCSM, it is evident that these institutions do not create a significant demarcation between the two. But as we will see, the problem of categorization and communication in these centres does not lie in the enmeshing of science and technology. Rather the question that requires attention is *what* science is represented and *how.*

1.4.1 Indian science/Western science: or should we create a distinction?

A question that must be on the mind of every science museum official in India is what kind of science should be on display. There are some major concerns related to this issue that need to be addressed: should the science being communicated be that which is regularly taught in school textbooks, given that the focus of the museums is on educating the public, or should it go beyond that? Is it necessary to clarify to young learners where the scientific outputs that they see on display originates from? And equally important is the language of communication: English or other Indian languages?

From the field trips to science museums managed by National Council of Science Museums that I carried out during my various periods of fieldwork in India--to Birla Industrial and Technological Museum and Science City in Kolkata; Visveswaraya Industrial and Technological Museum in Bangalore, and National Science Centre in New Delhi, the impression that I gathered confirms the speculation that the science on display is predominantly of western origin. This is because the museums and centres seek to present the most cutting-edge technologies and scientific research. A strong focus on industrial applications of science and technology is also present. Indian contributions to contemporary science, and Indian heritage in certain areas of science and technology (like

mathematics, metallurgy, boat-building displays at BITM[38]) also finds prominent mention in the galleries I have visited.

While the science centres try to incorporate the basic disciplines into their communicative fold (which include physics, chemistry; life sciences; as well as specific displays on technologies like electricity and railways) what seems to be lacking is a well rounded historical account of these innovations[39]. It is important to contextualize scientific inventions and innovations[40] and place them in the narrative of historical and social transformations. In several museums in Europe (on history of science and technology) that I have visited, this need has been addressed prominently, albeit, more often than not, from a local/national perspective. While I do acknowledge that the financial resources and objectives of museums in India may not be the same as their western counterparts, it would not be difficult for them to include a more well rounded story of scientific and technological development.[41] The problem lies with a common perception of what constitutes science and scientific temper, but that of course is an issue that does not come under the purview of this dissertation. The question regarding where postcolonial history of science lies, as David Arnold (2013) says, cannot be easily answered. In fact, he says the histories must be traced back to the western centres of scientific power. Kapil Raj (2013) urges historians to

[38] These were some of the areas of science and technology in which pre-colonial India made significant contributions.

[39] One can always argue that science centres are not required to adopt a socio-historical approach as their focus is hands-on training. However, in recent years, as mentioned by one of the officials of the Association of Science and Technology Centers (ASTC) in Washington, DC, the differences between science centres and museums are reducing.

[40] In this context, the interpretive approach adopted by Nathan Rosenberg (1983) is significant. Through his works, he challenges the notion of the lone genius at work in the creation of innovative technologies. He argues that the advancement of technologies has happened incrementally, and there are contributions of the multitude which get no attention. This is of importance in the context of how scientific narratives are constructed and distributed in India because most of the times the narration is that of technology transfer from the west and almost never about how the local populations assimilated them into their daily lives or what their contribution was to this process of engagement with foreign science and technology.

[41] In the recent years, NCSM exhibit designers are actively seeking to address this issue. In an interview with one such professional, he mentioned that in one of the new centres that has come up in Dehra Dun on the topic of Himalayas and its ecology, the gallery incorporates a well-rounded story taking into account not only the geographical and geological aspects but also the local and societal practices, all of which together narrate a more comprehensive story of the Himalayan ecosystem.

go beyond the centre/periphery argument because the exchange of knowledge has always been a much more complex affair. However, the question is: does the NCSM and its constituent science centres want to display a history of science and technology in India?

1.5 NCSM: the centralized unit for science communication activities in the Indian museum sector

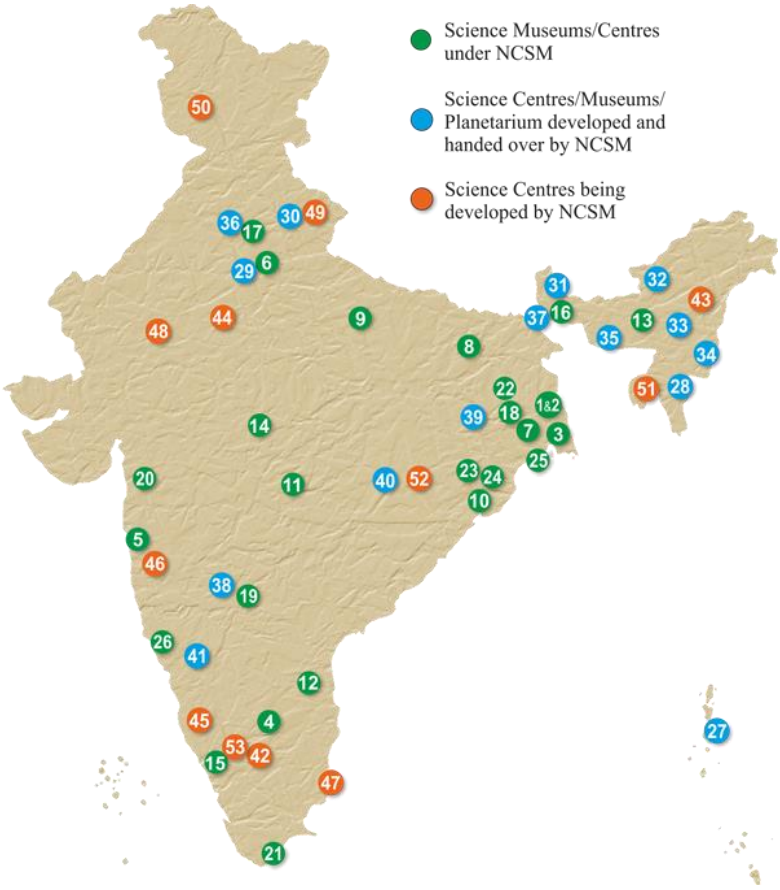


Image 1.1: Map of various units under the NCSM[42] (from the official website)

In this chapter, my aim is to introduce the NCSM as the main science communication institution in the museum sector. The following chapter is devoted to describing the NCSM's organizational structure, goals and functions and critically analyse its rhetoric of

[42] Official maps of India inside the Republic of India carry the state of Kashmir in its entirety.

communication. The website of NCSM states that it is the largest network of science centres and museums in the world. From the map in Image 1.1, we can see that the reach of NCSM is indeed widespread. Functioning under the Ministry of Culture (and drawing its funding primarily from it), the NCSM has been built to co-ordinate all informal science communication activities in the museum space in the country. Its raison d'etre is specified on the website as described in the section 'Genesis':

> The first science museum, Birla Industrial and Technological Museum (BITM), Kolkata under CSIR[43], was opened on May 2, 1959. In July 1965, the second science museum of the country, the Visvesvaraya Industrial & Technological Museum (VITM) was opened in Bangalore. After Kolkata and Bangalore, the work for the third centre at Mumbai was taken up in 1974. As the popularisation of science and technology through the Science Museums grew in scope and size, the Union Planning Commission[44] constituted a Task Force in early 1970's to assess the activities of the Science Museums. Task Force recommended to set up Science Museums in different parts of the country at National, State and District levels and also recommended formation of a central coordinating agency. In 1978, it was decided by the Government of India to delink from CSIR the two science museums already operating at Kolkata and Bangalore and also the one being set up at Mumbai and put them under a newly formed Society registered on April 4, 1978 as National Council of Science Museums (NCSM).[45]

[43] Council of Scientific and Industrial Research, an autonomous research and development organization in India which was established by a resolution of the Central Legislative Assembly in 1942, in British India.

[44] The Union Planning Commission was an institution under the Government of India, responsible for creating five-year plans to steer the economy of the country and allocate resources to sectors of national importance, and to assess the various resources of the country. Among other things, it was interested in boosting the human resources and hence science museums were considered to be significant institutions which could bring about societal transformations. When the present central government came into power in 2014, the commission was discontinued and a new institution was created, called the NITI Aayog, which is an economic policy think tank.

[45] This is the page that discusses the genesis of the organization: http://ncsm.gov.in/?page_id=636 (last accessed January 2017)

S Kumar, current director of the NCSM headquarters in Kolkata, in a personal interview said the following about the current state of the council's activities with respect to its continued commitment in creating new science centres.

> *The NCSM currently has about 25 science centres, including the headquarters and the Central Research and Training Laboratory (which is in charge of training the human resource, R&D for display and design, conceptualizing and fabricating exhibitions and displays as well as providing infrastructural know-how to all the other museums). Apart from these, the NCSM also developed a number of new centres in different regions (in the constituent states and union territories of India) and then handed over their administration to the governments of those regions. The decision to do so was taken around 2001, when the Ministry of Culture (under which the NCSM functions) realized that it was not possible for the NCSM, with available manpower, to manage all the new institutions which were being set up, given that the government suggested that each state and union territory should have science centres.*[46]

Here is the list of the centres which were set up by NCSM and then handed over to the respective states after the decision of 2001. These are categorized under the rubric 'collaboration'[47] in the council's website:

Science Centers/Museums/Planetariums	**Date of Inauguration**
Science Centre, Port Blair, A & N Island	May 30, 2003
Mizoram Science Centre, Aizwal	July 26, 2003
Nagaland Science Centre, Dimapur, Nagaland	September 14, 2004
National Agricultural Science Museum, New Delhi	Nov 3, 2004
Manipur Science Centre, Manipur	May 18, 2005
Arunachal Pradesh Science Centre, Itanagar	Dec 3, 2005

[46] All text from interviews will be carried in italics to distinguish between interview quotes and those from already published documents.

[47] The page with the list of collaborations can be found here: http://ncsm.gov.in/?page_id=711 (last accessed January 2017)

Shillong Science Centre, Shillong, Meghalaya	Feb 27, 2006
Maharaja Ranjit Singh Panorama, Amritsar	July 20, 2006
ONGC Golden Jubilee Museum, Dehradun	August 14, 2006
Kalpana Chawla Memorial Planetarium, Kurukshetra, Haryana	July 24, 2007
Sikkim Science Centre, Gangtok	February 22, 2008
Sub-Regional Science Centres, Kalimpong	October 2, 2008
Sub-Regional Science Centre, Solapur	February 14, 2010
Regional Science Centre, Ranchi	November 29, 2010
Dharwad Regional Science Centre, Karnataka	February 27, 2012
Chhattisgarh Science Centre, Raipur	July 13, 2012
Regional Science Centre, Jaipur, Rajasthan	December 29, 2012
Pimpri Chinchwad Science Centre, Pune, Maharashtra	February 8, 2013
Jorhat Science Centre & Planetarium, Assam	July 6, 2013
Regional Science Centre, Coimbatore, Tamilnadu	May 6, 2013.
Sub Regional Science Centre, Jodhpur, Rajasthan	August 17, 2013
Regional Science Centre, Pilikula, Karnataka	October 1, 2014
Sub regional Science Centre, Puducherry	May 3, 2015
Regional Science Centre, Dehra Dun, Uttarakhand	February 3, 2016

In addition, NCSM has developed the following centres and galleries outside India:

List of Centres/Galleries developed by NCSM (Abroad)	**Date of Inauguration**
Rajiv Gandhi Science Center, Port Louis, Mauritius	Nov 30, 2004
India Gallery on Buddhism, Kandy, Sri Lanka	Nov 6, 2013

From the dates of inauguration of a number of museums in the cluster, it is evident that the council has been very active in the last few years in setting up centres specifically in

suburban areas all around the country. What is equally surprising is how little attention, academic as well as media, has been paid to this phenomenon.[48]

1.6 Narrating stories of science with objects: case of the Railway Museum, New Delhi

The NCSM museums and centres were created for the purpose of engaging the Indian public with contemporary science and technology that affect their lives. In the official blog of the council, Gretchen Jennings, one of the foreign consultants to the institution writes: "Some museums are being very proactive in addressing current social and cultural issues. For example, NCSM museums have created excellent exhibitions to educate their communities on climate change and water conservation."[49] While social, cultural and environmental concerns have been and continue to be highlighted in the displays and outreach programmes of the council, there is a paucity of historical objects (and a historical narration using artefacts) in the galleries of the constituent museums. Thus, at the preliminary stages of my research, I was interested to find out an example where this narration happens.

The instance I found was the National Railway Museum in New Delhi. The Railways form an important part of India's industrial heritage, and in fact the two properties from India listed as World Heritage Sites connected to scientific and industrial heritage are connected to the Railways: the mountain railways of India (in Darjeeling, West Bengal) and the Chhatrapati Shivaji Terminus, one of the busiest railway stations in India built in an

[48] The next chapters will deal with the institutional structure of NCSM, its aims and objectives, and focus on one of its major national-level constituent museums, the BITM. As one of the many activities of the council, the fact that it is responsible for building science centres around the country is an important one which deserves a prominent mention. The council is in charge of the entire creation process of these centres. However, how these centres are managed then by the state governments is beyond the scope of this dissertation.

[49] See Smithsonian museum professional and frequent collaborator Gretchen Jennings's blog post 'Indian Science Museums: creative spaces with a long heritage', http://ncsm.gov.in/?p=2966 (last accessed February 2017).

amalgamation of Gothic revival and Mughal styles. The following short study of this museum has been carried out to highlight some of the main characteristics and drawbacks of museums in the country, as evident also from the public survey results discussed earlier. Do the NCSM centres suffer from the same issues? As there are so many of them, it would be difficult for a researcher to make a generalization. In the next chapters, some of these issues will be examined. However, for a broader and in-depth understanding of NCSM exhibits, one will have to carry out a longitudinal study of how the galleries have evolved over the years. This could be an apt follow-up topic to this dissertation.

Focus A: Research on history of Indian Railways and what the Railway Museum can draw from

The beginnings of formal scientific and technical education in India, in the sense of what is understood more commonly, read Western/European, are to be sought in the pages of the history of the period post 1870s. University courses in engineering started to be offered by multiple universities by the end of 1880s (Guagnini, 1993). Interestingly IIT Roorkee's history dates back to 1847, as the first technical school opened in Asia. Inkster (1998) says, the 'Minutes on Indian Education' delivered by Macaulay in 1835 was responsible in curbing the vernacular systems of knowledge which were prevalent then, and in formally setting up an English language system of education, which was more interested in training Indians to be employed in the civil services, or more strictly put, the services to the British Queen and the enhancement of the revenues. Furthermore, this implied that the industrialization carried out by the British in India was primarily a revenue making enterprise. It necessitates further debates regarding how much the British were willing to fund the changing social demands for the incorporation of scientific and technical knowledge and education, as the scientific institutions that Deepak Kumar (2000) writes about which grew in the last decades of 19th century could not have been set up solely with the money of private Indian entrepreneurs.

It is in this social milieu that one can locate the setting up of the training centre for mechanical engineers for railways in the same decade of 1880s. Why are the railways so important to the narration of Indian history of science and technology? It was one of the most significant technological changes that were brought about by the English to India. Again, one can draw parallels from history regarding the very similar timelines for the establishment of railways in nations like Britain, Germany, France and in India which got its first railway line in 1853. Here I will pause to consider the following quote: 'From 1850 to 1940, the construction, maintenance and operation of the railways employed at least one man for every two employed in all branches of modern industry … Estimates suggest that over a quarter of a million people were involved in railway construction in South Asia in 1861 with the cumulative total of the last half of the nineteenth century exceeding 10 million.' (Hurd and Kerr 2012,12)

A huge section of the population was assigned the task of the building of railways. But what kind of work were they doing? Was it manual labour or also the planning? What technologies were transferred in the process: both machinery and know-hows? Who were the engineers involved in this mammoth process? From Derbyshire (1995) we know that most of the higher technical tasks like bridge and tunnel building were done using Western technologies and the management was predominantly British. So, were Indians only employed to do the least technical jobs? Who were the institutions like the ones mentioned built for, then? Was it a sector that offered great learning opportunities to actors from multiple social sectors?

(continued on the next page)

My argument is that the history of training and technical education for railways can also be considered the history of the movement from the traditional to industrial sectors. In labour intensive India, before 1880, an average of 150 workers was engaged for each mile under construction. Most of the people were involved in manual labour but gradually a new class of technically competent people began to emerge thanks to the new training institutes. There was a transfer of knowledge and power and therefore the rise of social mobility through education or through employment. The new colleges, including Roorkee and other engineering colleges, set to train people for the Public Works Department (Kumar, 1995) were creating a new class of intermediaries or middle-tier engineers, as Indians were only accorded that position. Most historians opine that in the nineteenth century, at the very least, British officials were not keen on transferring power in terms of major decision making and supervision to the Indian engineers. A preliminary research on the social history of the establishment of railways in India already throws up these interesting facts and figures, which could be used by the Railway Museum to communicate the story of technology transfer between Britain and India. As the field of history of science continues to address the need for incorporating voices from the global south in the narrative of science and technology, museums in India need to make use of the existing research available in the various national and international institutions as well as promote further discussions/debates on understanding the production of science and technology as a collaborative enterprise between various actors from around the world.

The Railway Museum in New Delhi functions under the aegis of the Ministry of Railway, Government of India and is a space at the heart of the city where valuable artifacts significant to the history of colonial technology is showcased. The museum was opened in February 1977 to safeguard and display the heritage of Indian Railways, with a strong focus on the pre-independence history. The *Fairy Queen*, world's oldest working steam locomotive occupies the pride of place in its collection. The museum is spread over an area of 11 acres, with outdoor and indoor exhibits. The outdoor exhibits include over 90 vintage steam, diesel and electric locomotives, cranes and wagons. The indoor gallery includes miniature models of trains, interactive games and maps. The museum also offers additional services like 'toy train rides', locomotive simulators and a new restaurant, built as a part of the extensive renovation efforts carried out in 2014.The museum has an informative audioguide for almost all its major exhibits (which are left outdoors on railway tracks created specifically to house them), although the guide is designed for the use of adult visitors who have a sound knowledge of the engineering processes which have gone into the making of the objects on display.

As a museum which hosts such a large number of artifacts of great historical significance, it sadly has no comprehensive website of its own. A Google search shows up a result which says 'National Rail Museum Sites: Indian Railways' but it remains inaccessible. With a more thorough check, an incomplete website surfaces: http://ontesting.in/nrm/history.html The words 'railway', 'museum' or 'New Delhi' do not appear in this address, and hence it would likely not be considered by visitors.

In a 2007 article, Paul Marty writes that the number of visitors to the websites are almost ten times to that in the physical museum. As we can conjecture, this number will keep growing over the years. India cannot be an exception to this rule, given that its urban population consists of heavy Internet users, and therefore it is of utmost importance that there is a website for this museum[50].

Two of the areas of major required improvement which the public survey respondents indicated include better displays and better engagement strategies with visitors. These are, needless to say, crucial for effective communication. Especially when scientific objects are concerned, which require more specialized understanding of the objects, it becomes important to design the path for the visitors so that it can promote comprehension and appreciation. Scientific artefacts, however complex, can also narrate a story. 'That we put science and technology in museums suggests that both are highly valued, and form distinct expressions of culture within the society and that like art, there are physical artefacts which can somehow tell the story.' (Butler, 1992)

A museum must have a set of objects on display, even though science in itself is often too conceptual and complex to communicate by means of objects. This factor can also be extended to technological displays where the exhibits themselves cannot be appreciated unless there is an understanding of how the technology functions This is where design is of utmost importance in helping the visitor make meaning of the exhibits. Design helps in the mediation of meaning (Lupo, 2010). Borrowing this premise, I propose the following figure to explain the relationships between these entities:

[50] This is corroborated by the findings of the public survey where most respondents said they are most likely to use the museum website to gather information.

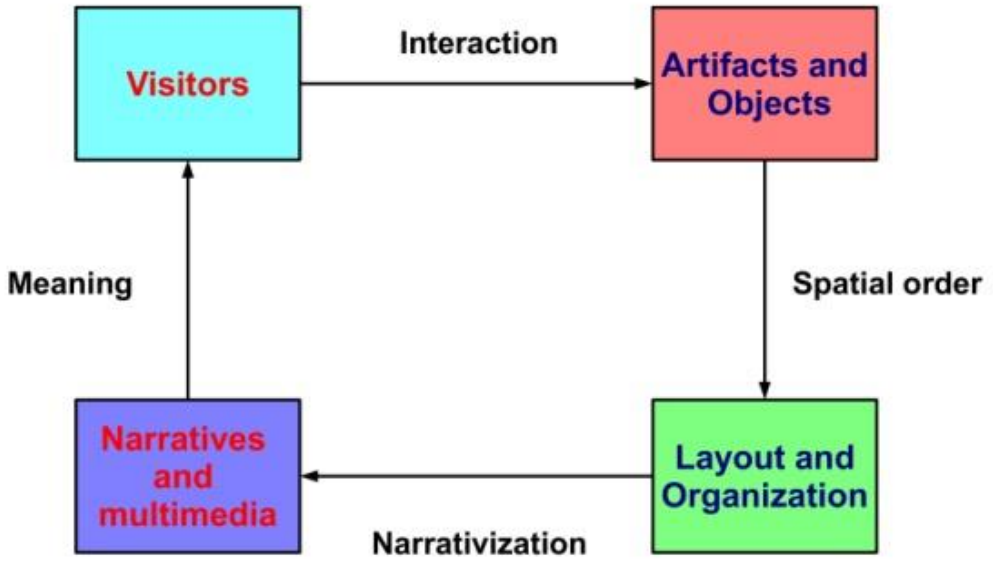


Figure 1.1: Meaning making in museums

One of the most significant voices in STS, Bruno Latour, in his actor-network theory talks about the 'actor' as someone who does not act on his/her own accord but is made to act by 'a vast array of entities swarming toward it' (Latour 2005). Visitors constitute one such actor in the museum. They encounter various stimuli, which not only includes the objects, but the way in which they are laid out, and the additional information provided in terms of multimedia enhancements. Their understanding is dependent on all these aspects coming together in the optimal form. I argue here that because the topic of communication, in this case, history of technology, is a rather difficult subject for most non-scientific visitors, the design therefore becomes a crucial tool which can either aid or abet the understanding.

Image 1.2: Display of a locomotive with the accompanying information plaque[51]

The problems of communication that can be discerned at the museum are not related to paucity of objects, information or tools that can communicate properly to the visitors the history of railways in India. As mentioned earlier, there is in fact a deluge of information on each object on display, and the number of objects is large. The tools are there: a well prepared audioguide, a toy train to go around the exhibits of the museum (especially keeping in mind the amusement of young visitors)—but to be effective further rethinking of their usability is necessary. For example, the audioguide serves little purpose for young visitors, and can also pose severe issues in understanding for a person from a non-engineering, non-scientific background. The language is too technical and evidently prepared by experts in the field who lack storytelling capabilities which is necessary to comprehend and appreciate such a technical history. There is also the issue of an

[51] Image downloaded from: https://www.google.it/search?q=railway+museum+new+delhi&safe=off&biw=976&bih=465&tbm=isch&imgil=-mmLYk_m6oXVaM%253BAAAAAAAAAAABAM%253Bhttp%25253A%25252F%25252Fmaps.mapmyindia.com%25252Fexplore%25252Fnational%25252Brailway%25252Bmuseum-new%25252Bdelhi-delhi-2bs8c5&source=iu&pf=m&fir=-mmLYk_m6oXVaM%252CAAAAAAAAAAABAM%252C_&usg=__lfU7A_E7YgUjTzFU6cz1XNTYR_k%3D&sa=X&sqi=2&ved=0ahUKEwjU4I6G8czRAhUpJsAKHbraDHwQuqIBCHswDg&imgrc=mNeJ2RHC_Tv89M#imgrc=14kU1fSWAJ82VM%3A (last accessed January 2017)

overwhelming number of stimuli; there is just too much information about the objects, and very little effort is put into telling the visitors why they are of such great interest.

In recent years, the museum has undergone a major facelift. There is now a downloadable app available on Google Play. The museum is experimenting with ICT to offer an enhanced visitor experience. New attractions include a miniature train which has 'locomotive simulators', a 'rail garden' which is a layout depicting the passage of trains through various terrains in India, passing through prominent stations of historical importance. The indoor section has also been refurbished with a focus on drawing a historical timeline of designs all the way from colonial times through the present, and even the future. The media reports note that the cost of the revamp has been about 24 crore rupees (approximately 3,3 million€)[52], however, they don't indicate if the entire amount came directly from the budget of the Ministry of Railways, neither do they mention the agency which was in charge of the renovation. One thing is clear that the museum's role in safeguarding and showcasing Indian Railways' heritage has been taken up seriously, and the museum has been modernised in keeping with the trend around the world to revamp and refurbish museums of national importance. The visit to this museum formed a part of my initial period of research in India, which I spent in tracing various types of collections and visiting different kinds of science museums around December 2013. All these changes prompt a revisit to understand if the enhancements are only design-oriented or also content-oriented.

It is important to mention here that there is also no attention paid to the fact that the enterprise of building railways in India was not solely a unidirectional process, a one-way flow of information. This is an issue which needs to be addressed by institutions like these around India, as the voices in favour of a stronger postcolonial understanding of history gain prominence. As is evident from annual logs of IIT Roorkee, the first engineering college in British India, as well as the writings of Derbyshire (1995), an authority on history

[52] See a detailed discussion on the revamped museum at http://indianexpress.com/article/cities/delhi/revamped-rail-museum-find-the-food-train-visit-rail-garden-chug-back-in-time/ (last accessed January 2017)

of railways in India, and of Raina (2011a) the setting up of railways in India required ingenious methods to tackle the terrain which British engineers were unfamiliar with, and these methods were developed in conjunction with Indian officials and workers. The history of engineering institutions in India also reveal a similar story where professors at the universities wrote some of the first syllabi which would contribute to the knowledge created in the disciplines of civil and mechanical engineering. The fact that they were created keeping in mind the peculiarities of India's landscapes and social conditions also need to be acknowledged. While this kind of heritage is not easy to be projected as displays, further information could be made available within the museum's premises. Also, to be considered here is the fact that the history of railways in India (as elsewhere) is as much intertwined with the socio-political-economic scenario of the times; and this contextualization is essential in a history of technology museum to get a sense of the narrative.

…

The National Council of Science Museums plays, or attempts to play, an enhanced role in the society. One of the sections in the following chapter will narrate the story of how NCSM was formed. To tell the story briefly: At the end of the 1960s, the establishment of the Exploratorium in San Francisco and the Ontario Science Center in Toronto ushered in a new age of science museums with focus on hands-on learning. Around the world, this model of science communication was taken up (Bandelli et al, 2009; Gregory and Miller, 1998). India was quick to adopt this model of science training for its vast and diverse population. The paucity of historical artefacts and the difficulty in locating them (Saroj Ghose, personal interview) coupled with the central government's mandate to promote contemporary science and technology and an inquiry-based discovery that science centres promote (ASTC, 2006), propelled this model into the forefront of all science communication activities which were undertaken from 1970s onwards.

While preserving the history and heritage of Indian science and technology does not occupy the central position in the mandate of the NCSM, the dissertation will argue that the council has established its own narrative of science and technology in India, with a strong focus on

what they mean to the society and how they can create possibilities for the future of a nation still finding its own voice and space in a fast-changing technological world.

Chapter 2. Interrogating the institution that is the National Council of Science Museum

In the introduction to a special volume on scientific institutions in modern India, historian Uma Dasgupta (2011) writes that while colonialism played its part in using science to administer large parts of the Indian empire, the respect for science and the need to cultivate a scientific outlook grew alongside Indian nationalism as a road to progress.

With the sustained importance of nationalism in the period of decolonisation after the Second World War, museums came to be recognised as powerful tools for radical socio-economic transformation (Ghose 1992; Venugopal 1995). The first two science museums in India came up, around 1953, in Pilani (in the Indian state of Rajasthan) and New Delhi, soon after the independence. In the former case, it was the initiative of the Birla Institute of Technology and Science to open a central museum on campus, and in the latter, it was the effort of the National Physical Laboratory to house a museum.[53] The first governmental attempt at defining India's scientific heritage and to promote science education was the establishment of Birla Industrial and Technological Museum (BITM hereafter) in Calcutta in 1959, in the decade following India's independence. As Saroj Ghose, erstwhile president of ICOM, explained in a personal interview, the need was felt by the central and state governments, and especially by the then Chief Minister of West Bengal, Dr Bidhan Chandra Roy, to preserve artefacts of historical significance in the newly formed state with diverse people. He was to a great degree influenced by the set-up at the Deutsches Museum which he personally visited and from this institution, he drew inspiration to form a similar one in India.

As it has already been indicated in the conclusion of the previous chapter, the opening of the Exploratorium in 1969 in San Francisco challenged the existing science museum space. The Exploratorium model of hands-on approach to science communication strongly favored science education and active participation in understanding of science. As Ghose explained further, for a young country with its policies firmly grounded on the needs of it

53Ingit Mukherjee (2003) National Council of Science Museums: 25 years of service to the nation. Kolkata: National Council of Science Museums (Special issue).

becoming self-sufficient, and to educate its large rural masses, the choice of model of science communication had to be one where education was foregrounded rather than science appreciation. The success of Exploratorium and the growing interest in activity-based science training also to cater to the needs of the rural population combined to create a major motivation for science museum professionals in India to propose this new institution as the preferred model of science communication, which resulted in the formation of the National Council of Science Museums (NCSM) in 1978.

Inspired by American museum anthropologist Peter Welsh's (2005) distinction of two fundamental divisions in the conceptualisation of museums—domains and circuits—this chapter is divided into two sections. The first section of the chapter will deal with understanding NCSM's definition of science and technology, with special focus on the clause of 'promotion of scientific temper' and the future-oriented goals that the concept of 'grassroots innovation' invokes. I will argue that the institution embraces the idea that India is still a nation-in-the-making with vast potential, and it is the task of public bodies to impress upon people the importance of their role in the nation-building process, which is precisely what the notion of cultivating scientific temper, or scientific reasoning seeks to do. Furthermore, my attempt will be to try and understand if the promotion of scientific temper can be considered as a legacy of independent India[54]. This section corresponds with Welsh's understanding of 'circuits', which addresses the way in which a museum orients itself through time. The idea of circuit is closely related to paths of possibility, or what the museum can become. As we shall see, NCSM and its constituent museums are constantly reconfiguring their role in the society, a characteristic further accentuated by their strong future-oriented approach.

In the second part of this chapter, I focus on the 'domains' of NCSM; in Welsh's definition, domains encompass the content that a museum communicates and the communities it addresses. My attempt here is a retelling of the history of NCSM's goals and objectives (which reflect on the content); its organizational structure (the networks which

[54] This notion will be discussed in detail in the fourth chapter where I consider the role of heritage and history in storytelling in science museums with cases from different countries.

communicate science); and the role that the Council plays as one of the main science communicators in the country (thereby connecting it to the public). Then I will specifically consider one of the constituent museums of the Council from the eastern zone, which is the Birla Industrial and Technological Museum (BITM), Kolkata, and examine the work that the Council undertakes, by analyzing the activities of the BITM[55] and its satellite units. My primary literature includes the in-house publications of NCSM, activity reports, special issues, articles written by NCSM professionals in journals and blogs, official website, alongside interviews I carried out during my stay in Kolkata. The Council receives full patronage (almost all of its funding) from the Ministry of Culture, which means that it is accountable to the central government for its activities, as well as the voting public. Online documents of the Ministry of Culture and NCSM agreements alongside the Ministry's budget has also been used for the analysis.

It is also important to note here that in Dasgupta's volume on the history of modern Indian scientific institutions, museums have not been represented. And yet, the NCSM is undoubtedly an unparalleled institution in the universe of science museums and centres (Bernard Finn, personal correspondence) insofar that a centralized attempt at organizing and managing science communication activities in museums is unique to NCSM. The Ministry of Culture's (Government of India) outcome budget document of 2016/17 describes the NCSM in the following words:

> NCSM is a premiere institution in the field of science communication, is an autonomous organization under the Ministry of Culture, GOI. Primarily engaged in popularizing Science and Technology and enhancing public understanding and appreciation of S&T through a network of science centres, Mobile science Exhibition (MSE) units, plethora of activities for public and students in particular, NCSM has now become a trend setter in the field of science communication both at national and international level. Presently, NCSM administers and manages 27 Science Centres /Museums spread across the country and is the world's largest network of science centres and museums that functions under a single

[55] In the following chapter, BITM will be taken up as a case study and its history, exhibits and activities will be discussed in greater detail.

administrative umbrella. (Ministry of Culture Outcome Budget, 9)

With growing importance of the public in science policies in India (discussed in some detail in the 'Introduction'), this seems to be an opportune moment to introduce NCSM as a case study whose aims, objectives and *raison d'etre* is to take science to people, and make people for science (NCSM Activity Report, 2008/09) thereby placing the voting public as the primary stakeholder of its service offerings.

Section I

2.1 Theoretical perspectives of NCSM's narrative of science and technology: aspirations, hope, future

The section is an attempt to present an analysis of the scientific narrative of the NCSM taking into account the political concerns of independent, post-colonial India. It also seeks to draw attention to the role of science and technology in the nation-building process of the India that we see today, the narrative being a legacy of governmental policies undertaken since the inception of the modern Indian state. In this analysis, I am keen to point out the centrality of science and technology in understanding the history and heritage of contemporary India.

Let us consider the following quote:

> At one level it was a world without shadows. We felt that the idea of the third world was invented for us to lead it. We had a copyright on both the past and the future. But what we were proudest of was our democracy, which we repeatedly said was the largest in the world. (Visvanathan, 1997)

With these lines, Visvanathan, a sociologist of science, captures the optimism of a newly independent country, free from its position and identity as the erstwhile 'Jewel in the Crown' of the British Empire and transitioning towards the modern nation-state with its inheritance of the largest democracy. He further goes on to discuss in the book that the modern nation-state is built on the principles of reason and science, crucial factors for its success. Using the abovementioned argument as the premise, in this paper, I will look at

the concept of science in the modern Indian state: more specifically, I will be examining the narration of science as conceived by NCSM. The Council is not only accountable to the government for its activities (as discussed earlier) ; it also formulates its idea of science based on national science policies. In its idea, does science constitute a body of aspirational knowledge for the future of the nation or is it a character-defining inheritance based on past accomplishments? In traditional history of science museums focused on highlighting past achievements, the second understanding of science prevails. From my reading of the publications (annual activity reports, special issues in Indian journals, visitor surveys) of NCSM and the interviews carried out with its management, it is apparent that the former notion of science, that of aspirational knowledge for a better future, has been embraced by the organization. This section will address some of the reasons why this notion of science gained prevalence in the Council, and will discuss some of the activities they have undertaken to promote their vision of science.

I will argue that there are two specific reasons which deserve to be studied in detail to understand the role of future in the formation of the Council's narrative of science. These include: the lack of consensus regarding what is India's contribution to its scientific heritage; and the need to explore the possible demographic dividends that a large young population can yield in a developing nation; which in turn gives rise to the rhetoric of 'scientific temper', or in other words, a scientific attitude towards thinking and problem solving to achieve goals. I will also argue towards the end of the chapter that 'scientific temper', a phrase which has been enshrined in the Constitution of India as a fundamental duty of every Indian citizen encapsulates the idea of technoscience in independent India and hence should be considered as a part of the technoscientific legacy of the Indian Republic.

2.1.1 Science as the narrative for the future (and not the past)

The first reason for the choice to promote science as an aspirational narrative for the future is, I argue, the lack of consensus on what is the Indian history of science and its role in the

social life of people. The Council itself admits that a large section of the Indian population is superstitious, and the vastly diverse demographic groups that they will have to cater to leads to major challenges in communicating science. This is also an interesting dichotomy of a modern nation-state with a very long and chequered history of conquests and their role in shaping local cultures. There is, as mentioned earlier, a whole gamut of varied opinion regarding what is Indian science. On the one hand, there are scholarly works on early calculus in fourteenth-century India (including Almeida and Joseph, 2004; and Raju, 2007) which are hardly known to most Indians and receive solely academic attention from historians of science. And on the other there are nationalistic political parties which seek to appropriate Hindu mythologies and religious texts to claim major scientific achievements like the creation of the aeroplane or that the first plastic surgery[56]took place in ancient India. In schools, the science taught is predominantly of western origin and is acknowledged as such with very little attention given to how the knowledge was transferred and what was the Indian contribution to the growth of western science. In this milieu, where the timeline of Indian heritage of science is either partial with stories from a mythical past or has an uneasy relationship with colonial heritage, the question of placing Indian history of science in a narrative of national scientific heritage becomes a difficult one to address especially in science popularization movements.

It is also important to mention here, if only as an aside, that the NCSM has not given up on history entirely. Robert Friedel, who has also been an instructor of the history of technology for the MSc course on Science Communication, that the NCSM runs says that: "*I've been very impressed by the centers' use of local heritage and traditions. A couple of examples that spring to mind are the centers in Bhubaneswar and Kurukshetra, where local traditions (typically with religious elements) are recruited for science center purposes. In*

[56] The attempt to appropriate stories from Hindu mythology as proofs of scientific invention in ancient India has been on the rise in the recent past, with the activities of certain political ideologues. This discussion merits an dissertation of its own. See for example https://www.theguardian.com/world/2014/oct/28/indian-prime-minister-genetic-science-existed-ancient-times (last accessed December 2016)

Bhubaneswar, for example, special attention is given to the sun and solar astronomy, due to long traditions of sun oriented worship (as I understood it)." However, he points out that "*the belief that modern science and technology are key to India's future and that the country is behind in making use of it and needs to catch up"*is crucial to understanding the activities of the NCSM.

If we look at the BITM, it is actually one of the two museums (the other is VITM in Bangalore) which retains the characteristic of both a science museum and a science centre. The BITM has a good collection of historical objects, some originals, some loaned and others replicas. In my interview with Dr Ghose, he recounted how in the initial stages of the setting up of the museum, as a young professional freshly returned from the Smithsonian, he had to coax collectors to part with their objects for the sake of the new museum that was coming up. Emdadul Islam, the Director of the BITM stated that while they are always keen on adding to the collection, it was not always possible to get hold of original objects, and hence they made use of excellent local craftsmen to create replicas of those objects from Science Museum, London and the Deutsches Museum. Islam was also quick to stress that in fact replicas were better for their purpose because they could create mobile objects, more suitable to the kind of demonstrations that they intended. However, as the education officer Mr Dileep Ghosh pointed out in another interview, the focus has increasingly shifted from science appreciation to science learning and some of the newer galleries like Mathematics and Biotechnology are created specifically for school learners to supplement their classroom work.

2.1.2 "Demographic dividends"

The idea of reaping demographic dividends which finds mention in many activity reports of the Council is crucial to understanding its activities; and as I argue, the second reason why the Council's activities indicate their strong focus on the future. In interviews with the Council's top management, almost every official mentioned the need for promotion of science and technology, from basic principles of natural sciences to knowledge of cutting--edge research in fields like robotics and nanotechnology, as they are the building blocks

for the billion plus population of India, a vast majority of whom is under 30. As Dr Emdadul Islam, Director of the BITM mentions in a personal interview, the need to sustain the drive for development was felt strongly as early as in the first decade after the independence, and this could only happen if the population was stimulated to take up science not only as a career, but also as a hobby.

In critical heritage studies discourses, it has been discussed that a young country interacts with its history differently as its interest lies more in the future than in the past (Winter, 2013). Saroj Ghose corroborates this point of view when he recollects in a personal interview that it was the government's decision to support the replication of the science centre model of popularization with its strong focus on education, and not the science museum model, which has its priorities in preserving artifacts and showcasing the historical achievements of the nation. It is also understandable that for a young independent nation, with a number of disputed claims of scientific achievements, it would be better to focus on a vision of science which could be co-created organically from within and ***democratically*** by its young population. In fact, it is also a telling feature of the Indian Constitution that the 'promotion of scientific temper' (or scientific attitude) is included as one of the fundamental duties of the Indian population to achieve the vision of a truly democratic state, based on the foundations of scientific/rational thinking.

Focus A: The NCSM-Smithsonian partnership

In the annals of the formation of the NCSM and its sustained role as a national institution of science communication and informal science learning, the Smithsonian played and continues to play an important role. To understand this link, it is necessary to start by addressing the close interpersonal relationship between Saroj Ghose, who travelled to the US in the early 1970s for research and would later go on to become the first Director-General of the NCSM, and Bernard Finn, then curator at the Museum of History and Technology (now National Museum of American History). This partnership has proved to be extremely beneficial for the NCSM, as over the years, many museum professionals from both India and the US have travelled between the countries, often making use of the US Government Rupee Fund. While it goes beyond the scope of this dissertation, but as a future project, one could work on the reconstruction the narrative of transfer of professional knowledge from the 70s till the present, between the two institutions, using the Smithsonian Archives and interviewing key individuals who have contributed towards strengthening the partnership.

One of the instances of knowledge transfer between these institutions is the continued collaboration of Smithsonian professionals alongside NCSM employees in creating materials for the Master's in Science Communication course developed by the NCSM. In some of the interviews which I already carried out (both with NCSM and Smithsonian officials), it became apparent that as far as integrating historical/cultural context in the presentation of certain topics was concerned, the NCSM sought help from the Smithsonian to prepare relevant material. In fact, an initial reading of the documents available at the Smithsonian Archives suggests that there are records of the top NCSM management visiting Washington DC to study courses on the history of science and technology.

2.1.3 Scientific temper: a utopian vision of the future?

The promotion of scientific temper, a crucial clause which finds frequent mention in the rhetoric of science popularization in India, is, I argue, the Council's primary activity to ensure that the demographic dividends can be reaped in the future. In fact, the phrase finds mention also in the previously mentioned outcome budget of 2016/17 of the Ministry of Culture, with reference to NCSM.

> National Council of Science Museums (NCSM) has been engaged in creating awareness on Science & Technology, developing scientific temper in society and promoting science literacy throughout the length and breadth of the country and engaging young students in creative and innovative activities. For last 35 years, the Council has developed a nationwide infrastructure of 48 science museums & centres to achieve these goals. Its outreach activities throughout the year aspire to develop a culture of science and innovation by engaging people from all segments of the society in the process of science & technology. (Ministry of Culture Outcome Budget 2016/17, 369)

Two specific activities of NCSM that 'aspire to develop a culture of science and innovation' will be discussed in conjunction with the promotion of scientific temper. The first set of activities include the Mobile Science Exhibitions, where exhibition buses with displays on various topics of everyday science and technology are sent out to the rural areas, whose audiences include some of the most disadvantaged sections of the population. Apart from challenging the idea of a museum space confined within four walls, these exhibitions support large scale dissemination of scientific facts in order to promote rational thinking among the poorest sections of the society. The second set includes informal laboratory sessions at the Innovation Hubs of select museums of the Council. These innovation hubs are targeted to serve the need of curious young students from schools and undergraduate degrees who want to gain hands-on experience in participating in wide--ranging technological projects like developing eco-bikes and line following robots to generating electricity from plant tissues.

In the narrative on scientific temper and how it is being promoted, the history of the Mobile Science Exhibitions (or MSEs) and how it became operational deserves substantial space, especially because the MSEs were a huge success with the rural population. This further strengthened the need for a dedicated institution to manage the diverse science communication activities in the country, spearheaded by the science museums. In the 60s

and early 70s, the two major science museums of that time, BITM and Visveswaraya Industrial and Technological Museum (VITM) based in Bangalore (the second major science museum established in 1965) in South India, started carrying out the first mobile science exhibitions (MSEs). These travelling exhibitions ventured out into small towns and villages to create scientific awareness. Each exhibition comprised the following resources and persons: a bus, a number of about 24 to 28 simple exhibits focusing on various everyday scientific phenomenon and uses of science and technology in daily life, a technician, an explainer and a driver. These travelling exhibitions on the Museobus also proved to be immensely popular and also created a target group of visitors distinct from school students. (Mukherjee, 2003) The present management of the NCSM however is quick to point out the sheer ambition of the MSEs, given that they manage to reach out to about 2% of the entire population. Their aim is to ensure universal awareness of science and technology and that scientific and technological facts and narratives need to percolate down to the common individual[57].

The Innovation Hub, one of the new projects of the Council, on the other hand caters to the young population of India, especially school and undergraduate students. The curator of the Innovation Hub at BITM explained in a personal interview that innovation networks are being created under the aegis of various ministries of the central government. He said that the discussion on innovation and how to promote it has gained massive momentum in the last years. In 2010, then President Pratibha Patil declared the decade till 2020 as the decade of innovation. This is an important step because concepts like 'local innovation', 'grassroot innovation' have been grossly neglected under the ambit of science and technology. As the saying goes, 'Necessity is the mother of invention', one has to understand that human beings innovate as per their needs and everyone has the capacity to innovate. In fact, the creation of new Innovation Hubs has been deemed a priority activity of NCSM as evident from the large number of hubs being created in the recent years. In the fiscal year of 2016/17, work on four hubs has been completed and 16 more are in

[57] In the following chapter, the history of MSEs will be discussed in conjunction with the history of the BITM, as the BITM was the first museum to design and carry out MSEs.

progress. (Ministry of Culture Outcome Budget 2016/17, 74).

From our discussion, the idea of nurturing the inventive, or more accurately, the innovative citizen became prominent, and this rhetoric is one of the most commonly used in modern nationalism (Edgerton, 2006), and I argue that India at the cusp of unprecedented economic and technological growth, has to make use of it. If one considers the pace of activities, it can be said without any doubt that the idea of future, at least for what concerns young India, is not just a long-range, long term vision. It is also being implemented at a frantic pace to cope with the demands of contemporary society. It is also evident from the above excerpt, the construction of science as a positive narrative of progress, specifically its importance in the direction that the nation will take in the future is considered a secure and foolproof narrative. In fact, some top officials say that they aim to create at least one science centre in each district of every region in India. The Council is increasing the number of constituent museums under its ambit by creating new centres to improve efforts in science popularization and reach every section of the Indian society.

2.1.4 Scientific temper or/as scientific heritage?

The purpose of the postcolonial science museum, at least what concerns the Indian scenario, has undergone a drastic transformation, aided by the changes inside the museum spaces and the approaches to science communication. If in the beginning (the 50s), the interest was to preserve the historic heritage of the empire, in the present the Indian science museum is more a science centre dedicated to provide affordable scientific education, and the creation of scientific citizens who will be able to address social needs innovatively. This opens multiple avenues for further research regarding the communication strategies required to harness the innovative potential of a large young population.

However, the question remains then: is the Council concerned with heritage and history of science in India? As we will see in the next section, one of the objectives of the NCSM, as mentioned in recent official documents, is to conduct research on traditional scientific knowledge and India's heritage in science and technology. The NCSM has mounted

travelling exhibitions in the past on India's culture of science. Most of the foreign professionals associated with the Smithsonian who have collaborated with NCSM have indicated in the interviews that the focus on presenting India's contribution to science and technology can be discerned in many galleries and exhibitions. Saroj Ghose however provided a slightly different view on this issue. According to him, scientific heritage and scientific temper are two ends of the science communication spectrum. The Council is interested in the latter. Presenting the Indian scientific past in contemporary times is not only difficult but at times even impossible. There is the problem of finding artefacts and then creating a narrative around it. Decades of little research in staking claims of authorship and ownership of scientific discoveries have only hampered the chances of uncovering Indian contributions to world science. It would seem that the Council thus is more interested in what lies ahead, and not what is lost in the vestiges of the empire. After all, this new version of science will be something that Indians can agree upon and claim stake in its development. Emdadul Islam, the Director of the BITM, on the other hand, said that heritage should not only be seen through the prism of objects and material culture. Heritage also lies in the practices; and in this context, it might not be too farfetched to argue that 'promotion of scientific temper', a phrase also enshrined as a fundamental duty of every Indian citizen in the Indian Constitution, is the intangible heritage of the still young Indian state, whose importance we are only likely to understand better in the years to come.

Focus B: What is 'grassroots innovation'?

In a 2011 presentation, Ramasami, then Secretary of the Department of Science and Technology (DST), Government of India wrote that India's Science, Technology and Innovation (STI) sector is heavily focused on addressing developmental needs. He also explains the reason why the rhetoric of innovation centres around the developmental discourse, by referring to the funding model for innovation in developed countries vis-a-vis India. In his own words: "Most developed countries invest about 2% of GDP into R&D with a share of 0.7:1.3 from public and private sector, respectively. In India, investments into R&D are at about 0.95% of GDP with shares of 0.7: 0.25% from public and private sector, respectively. Under such conditions, public and social goods priorities could drive the purpose of innovations and focus on "Affordable Innovations" for inclusive growth agenda of the country. (Ramasami, 2011)

This distinction is important as it helps us understand the thrust of the Indian government in defining 'innovation' along a narrative of inclusive development. Also, it is interesting to note that the public sector is still the major funding body for science and technology, which necessitates further discussions on how they should be viewed as public goods. Thus, at least for what concerns rhetoric on innovation, in India, the public seems to possess a large degree of agency, as is evident from the following quote, drawn from the 2013 Report to the People of the National Innovation Council (NInC), a think-tank which was specifically established for facilitating the creation of the innovation ecosystem. As we will notice, many aspects of innovation frameworks described by STS scholars are reflected in this objective of the NInC: The need to create a framework or an ecosystem which will focus on processes, which will provide an inclusive platform and will be driven by discourse among stakeholders also defines the basic tenets of the concept of 'grassroots innovation', which finds repeated mention in multiple policy documents pertaining to India.

I shall conclude this section by returning to the initial point of the birth of Indian democracy and the early optimism (which is still evidently present in the rhetoric of the NCSM reports as well as its institutional culture revealed through the interviews), recalling Arjun Appadurai's essay on 'Hope and Democracy' (2007). He argues that the politics of hope is strongly connected to concepts like participation, empowerment and social development. These are all important for a nation which is moving steadily from the status of 'developing' to that of 'newly industrialized'. The reality remains however one of stark inequalities on the ground with seemingly insurmountable social problems. This is where the Council seeks to make a difference: by promoting science and technology not just as specialized knowledge created by a select few but as processes which can be bettered

through training and applied to move towards an equitable society. With its innovation hubs and mobile exhibitions, the Council is on a mission to prove that anyone can innovate as the curator of the BITM's Innovation Hub claims. The notion that anyone can innovate reinvents the very approach towards science learning/popularization and as I argue, it represents the Council's vision for the future. However, as a final provocation and a point to think about for further discussions, I would like to look at the Council's narrative of science and technology once more, albeit from a slightly different perspective, especially regarding the issue of innovation and scientific temper. Can everyone truly innovate? I would go back to the Science and Technology Studies (STS) scholar Langdon Winner's (1980) essay "Do Artifacts Have Politics?" where he paraphrases the American sociologist and urbanist, Lewis Mumford, "...two technologies have existed side by side: one authoritarian, the other democratic, the first system centered, immensely powerful, but inherently unstable, the other man centered, relatively weak, but resourceful and durable". Is the Council, along with its constituent museums, promoting one or the other view or both?

In the next section, my attempt will be to shift from theory to practice: to understand the various highly involved stakeholders and the content of science that they are communicating. I will also discuss the notion of science communication as a public service as it emerges from the activity reports and interviews with the NCSM management.

Section II

2.2 Understanding the management, stakeholders and content of NCSM: from theory to praxis

We have already considered some of the reasons of the Indian government regarding the establishment of a centralized body, the NCSM, which controls science communication activities in the country through the management of a large number of science museums and centres. But what were the events leading up to the creation of the Council and its opening in 1978?

The first science museum, Birla Industrial and Technological Museum (BITM), Kolkata under CSIR (Council of Scientific and Industrial Research, which is an organization functioning under the Department of Science and Technology, Ministry of Science), was opened on May 2, 1959. In July 1965, the second science museum of the country, the Visvesvaraya Industrial & Technological Museum (VITM) was opened in Bangalore. After Kolkata and Bangalore, the work for the third centre at Mumbai was taken up in 1974. As the popularisation of science and technology through the Science Museums grew in scope and size, the Union Planning Commission[58] constituted a Task Force in early 1970's to assess the activities of the science museums. As Ingit Kumar Mukherjee, former Director of NCSM wrote in a special volume celebrating 25 years of the institution in 2003: "The task force brought to light the immense potential of the science museums for creation of scientific awareness and a scientific temper among the people at large and made several recommendations." For example, it recommended to set up Science Museums in different parts of the country at national, state and district levels and also recommended formation of a central coordinating agency. In 1978, it was decided by the Government of India to delink from CSIR the two science museums already operating at Kolkata and Bangalore and also the one being set up at Mumbai and put them under a newly formed Society registered on April 4, 1978 as National Council of Science Museums.[59] It is interesting to note here that the two public science museums in Kolkata (BITM) and Bangalore (Visveswaraya Industrial and Technological Museum or VITM) which are now a part of the NCSM were being managed by the CSIR before the formation of the Council. It is also evident that the role of science museums was perceived as crucial for the "wide educational purposes that it could serve" (Activity report, 78/79). After the transfer of management of the museums from the CSIR to the NCSM, the Ministry which was governing the science

[58] The Union Planning Commission was an institution under the Government of India, responsible for creating five-year plans to steer the economy of the country and allocate resources to sectors of national importance, and to assess the various resources of the country. Among other things, it was interested in boosting the human resources and hence science museums were considered to be significant institutions which could bring about societal transformations. When the present central government came into power in 2014, the commission was discontinued and a new institution was created, called the NITI Aayog, which is an economic policy think tank.

59 The webpage on the genesis of the institution can be found here: http://ncsm.gov.in/?page_id=636 (last accessed March 2017)

communication activities through the various tasks carried out by the museums also changed: from the Ministry of Science, then it would be under the Ministry of Education and Culture.[60] Since its inception, the NCSM has grown greatly around the country, with the Council developing a nationwide infrastructure for science communication and informal science learning. The number of visitors to the twenty-five museums and centres of NCSM has grown progressively over the years as well. In the 2013/14 Activity Report of NCSM, the number was recorded at over 9,1 million visitors to the various centres. In 2016, the Director of NCSM Headquarters revealed in a personal interview that another 15 million people participate in the various engagement and outreach programmes of the NCSM annually. While these numbers may seem small when compared to India's vast population as of now, it is clear that they are already significant for initiating discussions on the institution and its efficacy. Furthermore, with continued activity of building new centres and creating new engagement and outreach programmes, these numbers will grow in the coming years.

60Here it must be mentioned that after a reshuffling of ministerial roles and duties, now the Ministry of Culture and the Ministry of Human Resource Development (formerly, Education) are two separate entities, and the NCSM functions under the Ministry of Culture.

GENERAL STATISTICS AT A GLANCE

Museums/ Centres	Staff Strength	Floor Area (sq. mtrs)	Visitors to Museums/Centres
Headquarters	61	3000	–
CRTL, Kolkata	61	9000	–
BITM, Kolkata	103	9622	228760
VITM, Bangalore	93	11700	942749
NSC, Mumbai	89	17723	743729
NSC, Delhi	93	18773	708599
Science City, Kolkata	71	32064	1473036
SSC, Patna	23	5000	260315
RSC, Nagpur	22	4333	432184
RSC, Lucknow	28	8640	313829
RSC, Bhubaneswar	20	3819	230313
RSC, Guwahati	19	3903	382333
RSC, Bhopal	20	4000	179788
RSC, Tirupati	22	4035	234702
RSC, Calicut	21	2560	482208
NBSC, Siliguri	14	1925	249059
KPSC, Kurukshetra	14	4000	596848
Bardhaman Science Centre	13	952	172091
DSC, Purulia	11	1637	175091
DSC, Gulbarga	10	1500	147581
DSC, Dharampur	11	1550	241171
DSC, Tirunelveli	12	2130	345053
Dhenkanal Science Centre	10	1147	53268
Digha Science Centre	12	2589	368139
Kapilas Science Park	–	4.8 acres	30817
Goa Science Centre	14	2020	137810
TOTAL	**867**	**157622**	**9129473**

Image 2.1: Number of staff and visitors to all NCSM centres as of 2013 (Source: Annual Activity Report 2013/14, NCSM)

2.2.1 Reading the first activity report of NCSM

The fact that NCSM was accountable to the government and public funding is evident from its very first activity report of 1978/79. As this was the first year of establishment of the Council, a large part of the year was devoted to drawing up plans, policies, guidelines and setting up the institutional framework. Thus, the activities discussed in this report were those that were carried out by the existing museums of Calcutta and Bangalore, and the

new science centre in Bombay which was opened in 1978. The first report provides a detailed list of all the sixteen objectives of the NCSM, the permanent and semi-permanent galleries in the existing science museums and all its extension services offered already in its year of inception, including mobile science exhibitions, science demonstration lectures, science fairs, teacher's training programmes and science quizzes, among others. The report also mentions the number of personnel employed, a basic list of expenses and the organizational chart of the Council. From this what becomes evident is that while the NCSM was a new entity, several activities already existed before courtesy the science museums.

It is important to look at the 16 objectives a little closely as they reveal the grand scope and ambition of the Council and the reason why it was set up. Also noteworthy is the large number of objectives, which will be discussed after defining them.

1. To create and manage (and take over) new museums or centres of science, technology and industry at all level: national, state and district.
2. To establish centres for the development of science exhibits and demonstration aids[61].
3. To display the growth of science and technology and their uses in industry and human welfare.
4. To collect, restore and preserve important historical objects which represent landmarks in the development of science, technology and industry.
5. To collect, restore and preserve old records and documents related to the history of science, technology and industry with special reference to India and set up an archive.
6. To establish and maintain research and reference libraries in pursuance of the objects of the Society[62]

61 The fabricated exhibits in the permanent and semi-permanent galleries of the constituent museums and the demonstration kits are all created in India thanks to the Central Research and Training Laboratory, which is a national level institution under the ambit of the Council.

62 The NCSM as recounted earlier was established as a society. The first annual report states that the three science museums of Calcutta, Bangalore and Bombay were delinked from the CSIR by a gazette notification No. CD-261/78 in April 78 which resulted in the creation of NCSM. The new society became

7. To collect and disseminate information with regard to science museums and centres.
8. To preserve the relics of industrial archaeology as site museums.
9. To design, develop and fabricate exhibits, teaching aids and demonstration equipment for science education and popularization of science
10. To popularize science in cities, urban and rural areas for the benefit of students and common people by organizing exhibitions, seminars, popular lectures, science camps and various other programmes
11. To supplement science education given in schools and colleges and to organize out-of-school educational activities to foster a spirit of scientific enquiry and creativity among students
12. To organize training programmes for various sections of the society, including wide ranging groups like young entrepreneurs, technicians, housewives and teachers on specific subjects of science, technology and industry.
13. To render assistance to universities, museums, schools and other technical institutions in planning and organizing science museums and training people in the museum profession
14. To conduct research in the history of science and technology with special reference to India
15. To establish and award research fellowships and financing of specific researches in the relevant fields.
16. To publish scientific papers, books and journals devoted to museology, history of science and popularization of science.

While the scope of the objectives seems too large, it must be borne in mind that this was the first activity report, where clearly the NCSM was laying out all the clauses which rendered it not only important but also almost indispensable in national science communication activities. This is of course understandable given the fact that the NCSM was dependent entirely on public funding to be channelized through the responsible

functional under the Ministry of Education and Culture as indicated in the gazette notification No. CD-607/79 in September 79.

Ministry. The focus on education is overwhelmingly strong as well, which was the result of the Council coming under the rubric of Ministry of Education and Culture. As the annual report explains:

In order to make science museum an effective vehicle for popular science education and to bring about desirable changes in the scientific outlook particularly of the literate and semi-literate people in the urban and rural areas it is imperative for science museums to set before them certain broad objectives. The declared objectives not only help to identify science museums as distinct and identifiable social institutions but they also help to justify the growth and development of science museums in relation to their degrees of attainment of such objectives.

Apart from obvious goal-setting for accountability towards both the government and the public, the objectives in this first annual report clearly position the NCSM as an authoritative entity in charge of popularizing science and technology and promoting scientific thinking among a diverse population, many of whom have very little or no access to education. One of the issues that was mentioned multiple times in my interviews (that I carried out between June and September, 2015) with the top management of the Council, was that of curbing superstition. It is evident that for a country with as large and diverse a population as India, with varied degrees of access to formal education, science museums and centres can play roles of social change, even if very slowly. After all, what was mentioned in the first annual report continues to be a glaring issue today. However, as we will see, the Council has proliferated its activities massively through its current centres at the national, regional and district levels, and the mobile science exhibitions.

Here it must also be mentioned that in the most recent reports of the Council, the list of goals and objectives is not always reiterated. Case in point is the report from 2013-14, where objectives find no mention. However, the fact that some of them have been taken up seriously and some results can already be seen are evident. For example, the NCSM Society was created with three constituent museums under it. In 2013-14, that number had grown to 25 museums and centres, which is a huge increase in a matter of 35 years. Further to these, the Council is also creating other science centres as per the demands of the various states inside the Indian Union, whose management is then handed over to the state

governments. Secondly, from the list of community engagement programmes that the Council has conducted (as it is presented in the annual activity reports which I collected during my research period at NCSM) in conjunction with schools, universities, specific ministries of state governments, private companies and a whole range of stakeholders, it is evident that the goal of promotion of scientific temper/attitudes among people is being pursued relentlessly. Activities range from the comparatively ordinary (like science fairs, quizzes, demonstrations) to special (child marriage prevention programme and street drama on eradication of superstition, to name two). As the Annual Activity Report 2013-14 report states,

"In NCSM we believe that our mandate is to create a scientifically literate nation by showing what science is, what it means, why we need it. We remain ever committed to this task."

To understand the breadth of activities that the Council is involved with as extension services, the following tabulation can provide an idea. This is also to sum up this section, before moving on to the structure of NCSM. The three main rubrics under which we can classify the diverse activities of the NCSM are: activities for students, for adults and for the rural community. The following schema is taken from the second report of the Council (of 79-80). Under students, 'Innovation Hub' is the new addition, given the recent focus on building innovation networks which the NCSM is also a part of.

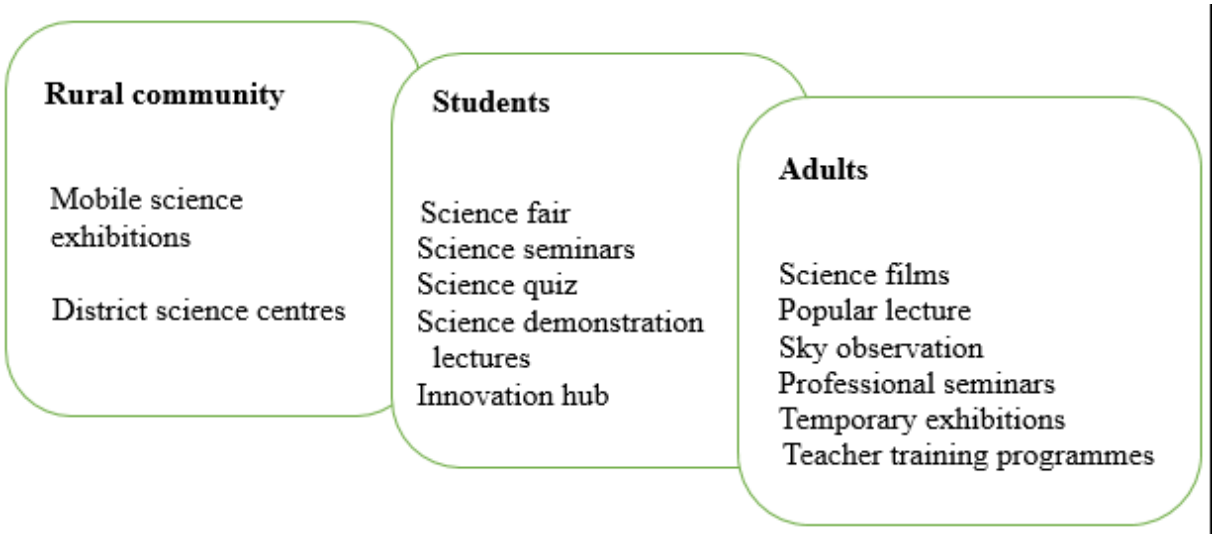


Figure 2.1: Outreach activities of NCSM

2.2.2 Management of NCSM: the decision-making body

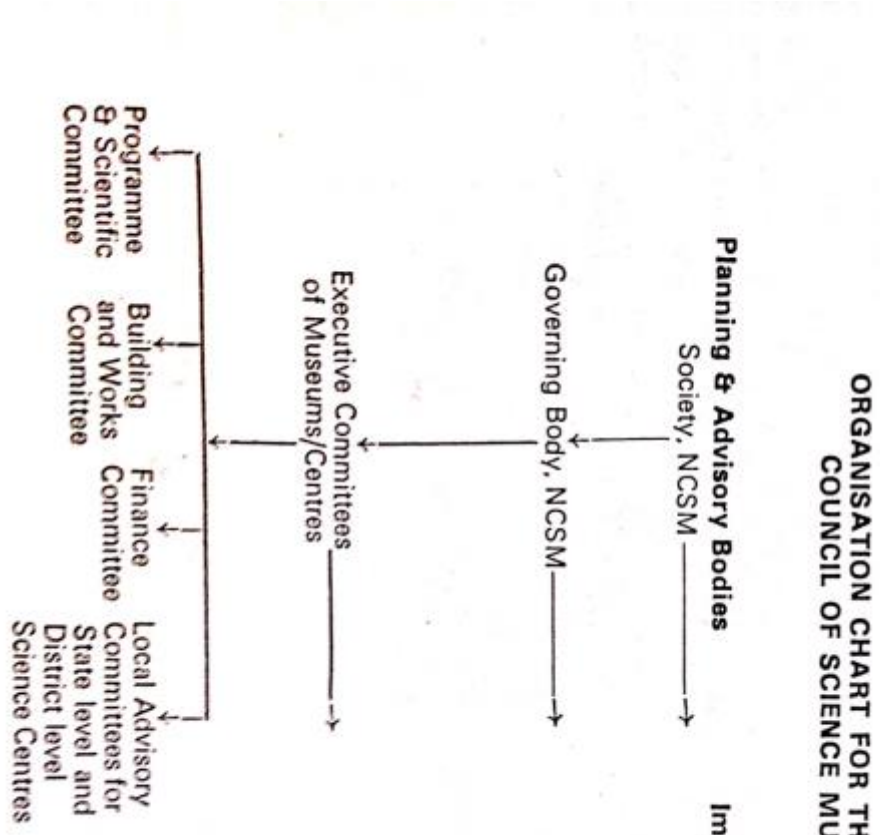


Figure 2.2: Organisational Chart of NCSM's top management and decision making team

In the previous page, a schematic view of the organizational structure of the NCSM has been provided. This only includes those in charge of creating, coordinating, approving content. In other words, this is the managerial structure of the Council, reflecting the top management. As is clear, there are two main groups which are in charge of realizing all the projects of the NCSM: the planning and advisory bodies and the implementation authorities.

Each step of the planning body also has a correspondent implementing authority as can be seen from the image. So the President of NCSM is the Union Minister of Culture who is also a part of the Society of NCSM (comprising the Director General of the Council, multiple scientists and university heads and other government officials along with the Union Minister). The Governing Body of the Council is a more compact version of the Society, in the sense that people from the Society form also the Governing Body, but not all of them. Here again the head is the Chairman who is in most cases a major scientist of national reputation. The Chairman is directly linked to the Director General of the Council who also has his own advisory Executive Committee. The Director General of the NCSM is the one individual who is in charge of all the decision making inside the organization. All the other committees indicated in the image are responsible for helping the Council and the Director General in all possible ways. It must be mentioned in this context that while the Director General is under the President (the Union Minister) and the Director (a major scientist), he is the real decision making authority regarding all the activities of the NCSM and all its constituent museums and centres. The scientist (in this case, the Director) and the Minister are there to provide him advice, but the Director General is the most important implementing authority. It must also be mentioned here that every constituent science museum/centre (at the national, regional and district levels) has specialized committees to advise it on new galleries and activities.

From this description presented in the previous paragraph, it would seem that the decision-making process in the Council is top down. This however does not explain the entire process. While the allocation of money is decided by the Ministry of Culture and therefore also the President of the Council/Union Minister of Culture, the decision to create new

galleries, upgrade facilities or to carry out specific activities happen at the level of the individual institution. So even if in terms of financial allocation, the Council is clearly dependent solely on the Ministry, the decision-making process for new projects and everyday management follows a bottom up approach. This was explained by Emdadul Islam, the Director of the BITM, Kolkata, when we discussed how the funding is allocated and decisions are taken regarding new projects/galleries/exhibits in the museums and centres which report to the BITM, which is a national level institution under the Council, and co-ordinates in return, the activities of eight other units which all form together the centres of the East Zone (see figures 2.3 and 2.4).

Here is a summary of the interview with the Director of BITM on this issue:
BITM has eight centres under its control (also called satellite units) as it is the national level centre and the zonal headquarter of the east zone[63]. However, all new activities for satellite units are proposed by individual centre heads. Thus, it is not the headquarter which dictates new projects to the satellite units. For example, the centre head of the Bhubaneshwar Science Centre in Odisha (another east zone state) creates the annual plan. After the plan is created, there is a meeting with of the director of the zone, finance officers, civil engineers (in charge of building and maintenance), centre heads and a headquarter coordinator from the BITM to discuss budgets and plan feasibility. Each centre's budget comes to the BITM, and then from the headquarters, a very detailed budget requirement for that zone is drawn. Each zone also has its own executive committee (parallel to the governing body for the Council), which discusses the budget (alongside the financial advisory committee) before passing on to the governing body. Finally, once the governing body approves, the budget is delivered to the Ministry of Culture, which is then passed on to the Finance Ministry and finally to the Parliament. The approval of the budget comes from the government. Here it must also be mentioned that most of the administrative support for the satellite units comes from the headquarters. The regional level and district level centres (satellite units) have their own heads, but primarily they are in charge of

63 BITM's administration is in charge of its own museum, which is the eastern zonal headquarter located in Kolkata, along with seven other centres from the zone located in the eastern states of West Bengal, Bihar and Odisha.

education programs in their respective areas, and the fabrication and maintenance of their galleries. This is reflected in the staff composition as well. However, as mentioned earlier, the preliminary plan is drawn by each satellite unit, which is then sent to headquarters where the plan is finalised before moving higher up the hierarchical ladder. Thus, while the funding comes directly from the government, the decision-making process is anything but top down.

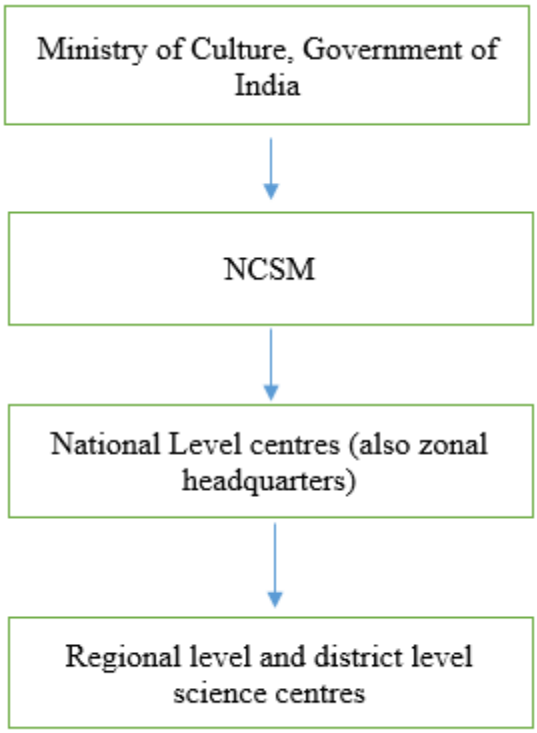


Figure 2.3: Flowchart of hierarchy of centres under NCSM

2.3 Understanding the Birla Industrial and Technological Museum as a museum and administrative headquarter of the East Zone

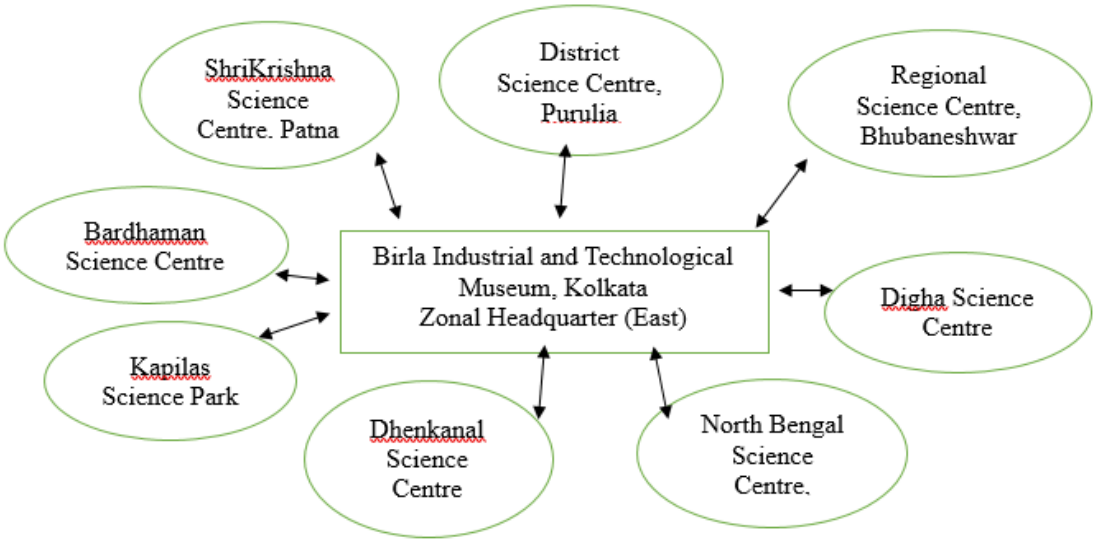


Figure 2.4: BITM and its satellite units

As mentioned earlier, the Birla Industrial and Technological Museum was the first public science museum established in Calcutta, India in 1959. It was set up to be an Indian parallel of the Science Museum, London and the Deutsches Museum, Munich (thus its focus was defining an Indian history and heritage of science). Today however, the institution embodies features of that of a science centre and a science museum (Islam, personal interview). Thus, while it continues to tell stories of history of science and technology, it focuses strongly on school education and lifelong learning. Its list of activities is not limited to creating and upgrading galleries and exhibits, but also facilitating the creation of new avenues for different sections of the population to engage hands-on with science and technology. As a unit of the Council, the BITM is also mindful of the new scientific and educational policies of the Government of India. In a personal interview, the curator of the comparatively newly formed Innovation Hub at the museum, Mr Saha, explained the national-level networks the BITM is a part of with respect to the spread of concepts like 'frugal' and 'grassroots innovation'.

The National Innovation Council (see Focus B of this chapter for further details) was formed to chalk out plans regarding how to develop centres around India to promote innovation. The council selected some of the NCSM science centres alongside other scientific institutions for this task. As the science centres already promote public understanding of science and technology, they were felt to be optimal for popularizing the concept of innovation among visitors and the larger civil society. In 2012, the NCSM started working on the project of creating Innovation Hubs, initially, at the national level science centres. The one at the BITM was completed in July 2013 and was opened to the public in August 2013. All the planned hubs were completed within 2013-14.

This discussion also brings us back to the question of the organization of the Council and the importance of the national level centres. As mentioned earlier, the BITM is one of the national level centres, and the headquarter of the Eastern zone[64]. Thus, apart from managing its own activities, the museum is also in charge of the overall administration of the satellite units under it (see figure 2.4). The centre heads of each of the satellite units are considered as project coordinators. The Director of the BITM is also the head of the administration for all these units. The close relationship of the headquarter and the satellite units is strongly evinced by the fact that the annual activity reports of the BITM also carry information about all the other centres under its supervision.

Following Figure 2.4, we can see that the BITM manages eight other units in the three east zone states of West Bengal, Bihar and Odisha. These centres are located in towns and semi-urban areas of varies sizes. Thus, while Patna and Bhubaneswar are capital cities of Bihar and Odisha respectively (with population of 1.3 million in Patna and a little over 600,000 in Bhubaneswar), Bardhaman and Purulia are districts (smaller administrative divisions inside the state of West Bengal) and Digha is a locally famous tourist spot, a semi-urban area. The North Bengal Science Centre located in Siliguri, West Bengal is yet another regional level centre as is Dhenkanal Science Centre and Kapilas Park (both of which are in the small town of Dhenkanal, Odisha of about 60000 people). It must be noted here that

64 The other zones are North, South and West.

out of the eight satellite units, four are in West Bengal, the state where the BITM is also located.

From the Activity Report of 2013-14, another issue becomes prominent. That is, there is no apparent correlation between the size of the population of the place and the number of visitors to a centre. For example, in the year of the report, the maximum number of visitors at 368,139 was recorded at the Digha Science Centre, probably the most sparsely populated among all the locations. However, as mentioned earlier, Digha is a popular tourist attraction for people from West Bengal, and this implies that a number of visitors to the centre were tourists. Three other centres, namely, Bhubaneswar, Patna and Siliguri registered higher number of visitors than the BITM (whose own number was 228,760). Even more interesting was the number at the Purulia District Science Centre, which is one of the most sparsely populated areas in West Bengal. The number there was 175,091 which is not very different from that of the headquarters. This also shows us that the regional and district level centres are extremely important to the ecosystem of science museums and centres, and it takes us back to the initial part of the paper, where the goals of NCSM are discussed. As the Council has been actively trying to promote science and technology and more importantly a rational, scientific way of thinking among different section of the population, including the huge rural populace that India has, evidently their objectives are reaching some kind of fruition with the smaller centres registering high number of visitors, even greater than the BITM which is located in a metropolitan city like Kolkata, the most important urban centre in Eastern India.

2.4 Science communication and informal science education as public service

The NCSM is a public non-profit organization which derives its funding from the government, even though the phrase ‘non-profit’ is not to be found in its reports, and in fact, the annual activity reports do not carry the income statements. However, the details of funding that the NCSM receives, or at least what it has received in the past fiscal years

is available online in the Ministry of Culture website[65]. A close reading of the documents available online reveals that the amount has slowly yet steadily increased over the last few years (or at times stayed stable, but has not reduced). In the Ministry's outcome budget of 2016/17 where the targets of the present fiscal year are discussed, there is a section which deals with performance evaluation of the previous year 2015/16. In this section, we get an idea of actual numbers of the budget allocation for NCSM (that is, the headquarters and all the constituent museums/centres under it), which has the largest share of the budget when compared to the rest of the institutions under the patronage of the Ministry: Rs. 46 crores (6,5 million € approximately) was allocated to meet the 'non-plan' section of the NCSM budget, which includes administrative and establishment expenses. Another Rs. 42.5 crores (6,02 million € approximately) were made available for the 'planned' part of the budget which is used for developing new programmes, activities, galleries, exhibitions and commemoration of special days and events. These numbers show growth in terms of allocations when compared to 2014/15, also available in the same document, where we find that Rs. 42 crores were allocated for non-plan and 33.75 for planned section of the budget.

Growth of NCSM Budget (Expenditure)				
F-Y	Plan	Non Plan	Total	Growth %
2009-2010	2316.03	4352.35	6668.38	xx
2010-2011	2735.92	4306.27	7042.19	5.61
2011-2012	3211.58	4620.81	7832.39	11.23
2012-2013	3252.50	5342.35	8594.85	9.74
2013-2014	3068.33	5733.71	8802.04	2.42
Average Growth of Budget over a period of 5 years (F -Y)				-------- 6.34%

Image 2.3: Growth of NCSM budget and expenditure over the last five years (Source: Chaudhuri 2013. All figures are in lakh rupees. 1 lakh=100.000)

[65] This is the comprehensive budget of the Ministry of Culture which includes information on allocation of funding for all the institutions which receive its patronage. These include museums, libraries, archives, cultural and educational institutions.

While the Ministry continues to operate as the main funding body of NCSM, the Council has other avenues of earning revenue, as the Director of NCSM Headquarters explained in a personal interview.

> *Apart from central government funding, we also receive money from state governments/organizations for specific programmes. NCSM also earns revenue from offering consultancy services to other organizations (for example setting up a new museum, gallery) and this is about 20% of the project fee. For science fairs, science seminars, we receive private sponsorships as many organizations are interested in scouting talents through these. Also, at times when exhibitions travel abroad, costs are covered by the host museum. Extra revenue is also generated from license fees for some of the services such as catering, operation of souvenir counters etc. These additional funds are generated to meet our non-plan expenditure which has been increasing on year to year basis.*

Like any public museum, NCSM and its various units are duty-bound to serve the citizens, or more specifically, the voting public (Glaeser, 2003). As the nature of public non-profits goes, it is dependent entirely on government funding, and it invokes images of a community and more importantly civic dependability (Lipsky and Smith, 1989). From the structure of the NCSM discussed in the earlier paragraphs, it is evident that the decision-making process follows a bottom-up approach when it concerns new exhibits, maintenance of old galleries and various kinds of outreach community activities, while its funding is essentially top-down. There are a couple of arguments emerging from the management of museums and similar organisations, that deserve to be mentioned in this context. In non-profit sector management literature, it is assumed that: "to the extent that reliance on government funding reduces the representativeness and influence of nonprofit boards, the democratic function of nonprofit organizations may be severely constrained." (Guo 2007, p.458). In a museum management journal, science communication specialists Bandelli, Konijn and Willems (2009) argue that while science centres and museums are increasingly developing strategies to be more inclusive of the visitors' voices, existing models of museum governance do now allow the visitors to have a formal voice in the decision-making process. At this juncture, it is important to ask then:

1. Does the complete reliance on government funds reduce the influence of the governing body?
2. If that is so, is there any possibility of having the public voice represented in the decision-making process?

It is beyond the scope of this chapter, and indeed, this thesis to delve into the complex world of Indian politics, and more specifically, the role that political parties play in managing the most populous-democracy in the world with multiple societal fault lines. There is no doubt that the government in power has the possibilities to heavily influence the activities of NCSM. Also, given that this is a public institution, it is expected to work in close contact with other similar institutions, and the Ministry of Culture which is the funding body of NCSM works alongside Ministries of Education, and Science and Technology to promote science communication. If we look at one of the latest Memorandum of Agreement signed between the Ministry of Culture and the NCSM, we can observe the 'responsibilities, performance indicators and targets duly agreed by both parties' (MOU 2015/16). As per the document, the organisational objectives of NCSM have not significantly changed from the aims we found in the very first activity report, even if the number in absolute terms has reduced. Let us take a quick look:

1. To portray the growth of science and technology and their application in industry and human welfare, with a view to develop scientific attitude and temper in the society
2. To popularize and create awareness on science and technology
3. To supplement science education given in schools and colleges to foster a spirit of scientific enquiry and creativity among students
4. To conduct research in science and technology in the areas pertaining to the activities of the Council and to evaluate traditional science and technology in the light of modern scientific and technical concepts
5. To establish centres for development of science exhibits and demonstration aids
6. To render assistance to universities, technical institutions, museums, schools and colleges or other bodies in planning and organizing science museums and also in training of personnel for museum profession
7. To collect, restore and preserve important historical objects which represent

landmarks in the development of science, technology and industry.[66]

It is to be noted here that the major inclusions in this seven-point agenda vis-à-vis the list of aims in the first annual activity report of the NCSM are the clause of developing a scientific attitude and scientific temper; and the focus on exploring Indian science and technology with a thrust on indigenous knowledge. It must also be mentioned, that the clause about inculcating scientific temper and attitude, as well as exploring Indian contributions in science and technology, have been reiterated through various subsequent activity reports.

Yet another crucial objective of the NCSM is that it is supposed to provide assistance in science communication activities to other institutions (both public and private) of learning. This clause reflects NCSM's important role as a broker of science communication activities in the country, connecting schools, universities, technical institutions, other museums, think tanks, government and the public. A quick glance at the activity reports through the years will tell us that apart from creating and maintaining galleries, the constituent members of NCSM are also in charge of conducting a vast array of public engagement programmes. These include special programmes for students like science seminars, science drama competitions and science quizzes which are conducted at the local, zonal and national levels. For visitors to the various centres in cities and small towns, there are community programmes which mainly highlight various health and environmental issues, like AIDS awareness, discussions on water scarcity or the need to prevent child marriage. There are also instances of special events for children living below poverty line.[67] For teachers, there are the teacher-training programmes which are designed to help teachers engage better with students on issues related to effective science education inside the classroom. These programmes are conducted every year at various centres where teachers are trained to use new communication tools and strategies for ensuring better science communication in Indian classrooms. The range of activities may seem overwhelming at

[66] For the full text of the memorandum of agreement of 2015/16 between the Ministry of Culture, Government of India and the NCSM, see: http://indiaculture.gov.in/sites/default/files/MoUs%20Museums/NCSM-15.pdf (last accessed February 2017)

[67] See NCSM Activity Report 2013-14.

first glance, but when read from the perspective of promotion of scientific temper, it is understandable that the institution has engaged in a multi-pronged approach to ensure that a strong narrative about science and its role in the society is communicated to the people. As the present director of BITM sums it up: the aim is to take science to people and make people for science.[68]

This is also where the question of the public in public understanding of science needs to be discussed at some length. Who is the public in public understanding/engagement in science? Reading the previously mentioned article of Bandelli et al (2009)[69]closely, we find a definition of the public: "… those people who make use of the space, programs, and exhibitions that the museum can offer or that might do so." The article goes on to mention that the public includes not only visitors and potential visitors but also other stakeholders like educators, donors, volunteers and civil society organizations. In Public Understanding of Science and Technology (PCST) literature, the discussion on how to communicate to the public has shifted from 'understanding' to 'engagement/participation', or as scholars in this field have argued, the movement has been from a 'deficit' model which prescribed educating the lay public to improve their general knowledge about basic science and technology[70], to a 'dialogue' model which acknowledges and encourages public's competencies. (eg. Miller, 2001; Wynne, 1992). This has led to transformations in communication strategies of science museums as well. Citing Sandell (2003), Bandelli et al (2009) argue that museums need to also become more inclusive by understanding their

[68] This is also the opening line of the NCSM Activity Report 2007-08.

[69] Here it is important to mention that there is a huge paucity of research on management of science centres. Most discussions on science centres are to be found in the literature on public communication of science and technology (abbreviated as PCST), but they seldom deal with managerial aspects.

[70] In the Ministry of Culture's budget outcome of 2016/17, the NCSM finds prominent mention as the institution in charge of promoting scientific temper as well as scientific literacy. Thus, one could argue that the deficit model of teaching people science as there is a lack in knowledge is still adopted by the institution. However, in the NCSM documents, the word 'deficit' finds no mention. It is expected that people will want to cultivate scientific temper (as it is one of the ten fundamental duties of every Indian citizen as prescribed by the Constitution of India). In this way, the expectation is that institutions like NCSM will work in helping the public to realise this constitutional goal. For further details on the budget, see http://www.indiaculture.nic.in/sites/default/files/budget/Outcome%20Budget/2016-2017/Outcome%20Budget%202016-17%20(English).pdf (last accessed February 2017)

role as agents of social dialogue, and incorporate voices from diverse socio-economic groups. Have these challenges been taken up by the NCSM? It would seem from the rhetoric of the organization as evident in its agreements with the Ministry or from its annual activity reports that it is fully aware of its role as an agent of social transformation. In other words, it upholds science communication as a public service[71]. While present literature in science centre/museum management assess the managerial boards of centres as (at times) resembling those of Wall Street (Bandelli et al, 2009) or that the directorial jobs revolve mainly around fund-raising and ensuring efficiency (Griffin, 2008), we find a distinctly different model of governance in the Indian context. Is it possible that certain sectors are still considered better off when they have the stamp of the government? Especially when it concerns the question of education, and specifically science education, it seems that the nation-building narrative has been strongly upheld by the government and the NCSM.

[71] As we have seen through the discussions in this chapter, the NCSM is reaching out every year to more number of people, and arguably also more sections of the society, through its multiple outreach efforts.

Chapter 3. Understanding the rhetoric and activities of the Birla Industrial and Technological Museum, Kolkata

In the previous chapter, the role of BITM as a constituent unit of the NCSM has been discussed. In this chapter, we turn our attention to the museum itself, which holds an important place in the history of Indian museums as the first public science museum in independent India. To address the history of the BITM, this chapter makes use of the museum's in-house publications, archives of both BITM and NCSM and interviews with various highly involved stakeholders working at the museum. After the narrative account of the history of the institution, the chapter will move deep the BITM's physical space and review two of its galleries, Transport and Mathematics, as well as evaluate responses from a public survey carried out by NCSM officials, thereby providing a sense of how visitors perceive the content and the service of the museum. In the final section of the chapter, two extension activities of the BITM[72], the Innovation Hub and Mobile Science Exhibition will be discussed and the role of the BITM in promoting 'scientific temper' (which as the second chapter explained is one of the main objectives of the NCSM) will be examined further.

3.1 BITM: the historical trajectory

> BITM has played an important role in enhancing public understanding and appreciation of science in addition to playing a pivotal role in offering non-formal science education to young audience during last 50 years. It has also played a key role in catalyzing a science centre movement in the country both in terms of developing high class professionals to man the new science centres that came up after BITM and in supporting new initiatives to develop new science centres. BITM

72 These activities are not unique to BITM as we saw in the previous chapter, especially in the first part where the goal of promoting scientific temper was discussed. As a national level centre and a zonal headquarter, along with Mumbai, Bengaluru and Delhi, BITM is in charge of managing the museum buses for its zone (East), and also the first to provide the space for Innovation Hub in the zone (like the other national centres).

> is also known for its role in taking the message of science to rural areas through its mobile science exhibition programme and other education extension activities. (Ambika Soni, Union Minister of Tourism of Culture writing on the occasion of 50 years of BITM in a special issue published by the museum in 2009, p.5)

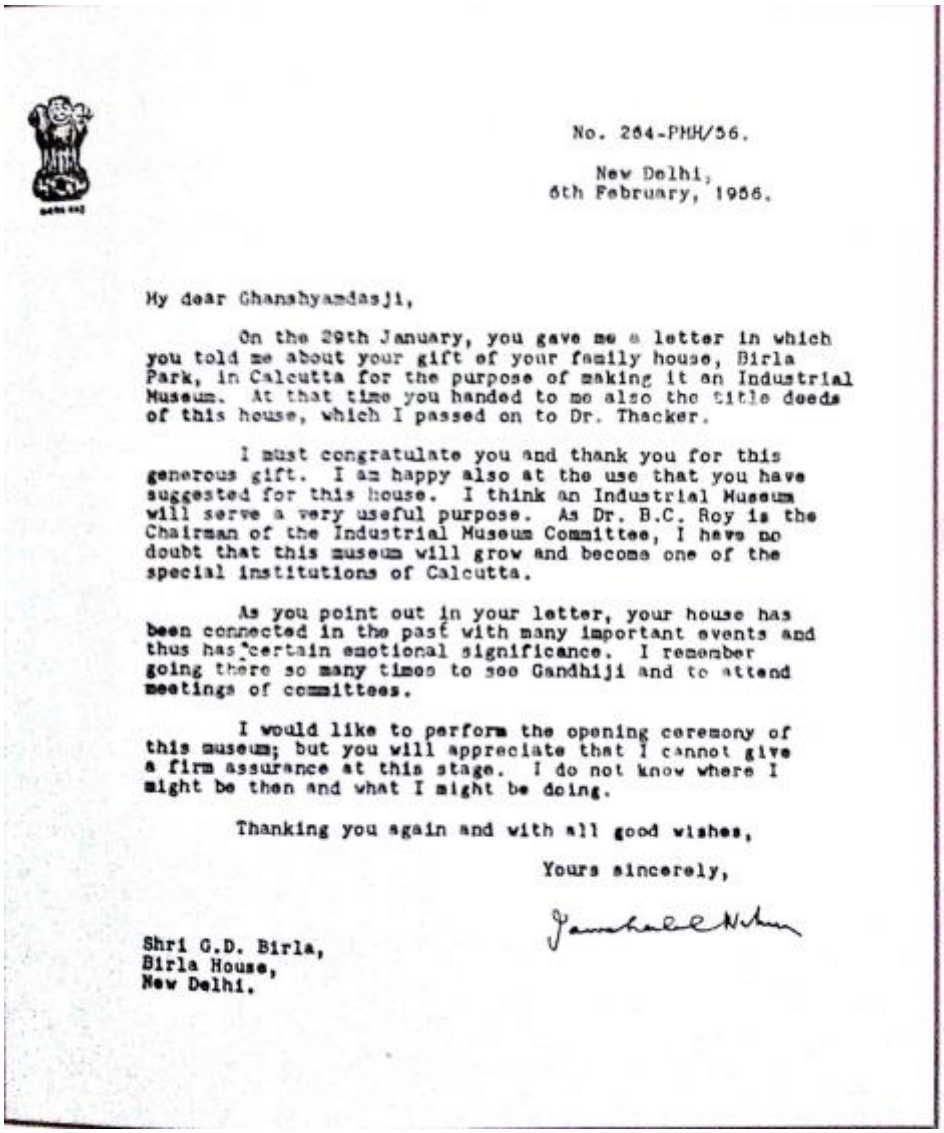
In this message from the minister, the role of the BITM in the national science popularization movement becomes apparent. The museum has not only been a place where students have benefitted from informal science training, but also where professionals have been trained to follow a career in science education. It has catered to the needs of multiple groups: not just those in the cities but also in the villages and far flung areas of the country through its mobile science exhibitions. In terms of engagement of the public with various topics and debates in science and technology, the BITM has always managed to update its scientific narratives along with the social needs of a specific time and place. Arun Sharma, erstwhile chairman of the executive committee[73] of the museum writes in the same issue on the wide range of science and technology topics addressed at the BITM, with a strong focus on their role in the society:

> During my deep association with BITM for almost a decade, I felt deeply privileged and was amazed at the innovative strategy which Dr Saroj Ghose, DG, NCSM, Shri S Goswamy, Director, BITM and their colleagues adopted with enthusiasm to fulfill the mandate of the institution, which cover encouraging creativity, promoting the culture of science, the awareness of bio-diversity and interdependence of all components in the biosphere, contemporary events such as climate change and global warming, technological innovations such as basics of biotechnology on the one hand and information technology on the other and even introduction to space journey. (50 years special issue, p.9)

The history of the nation-building process (during the early years after the formation of the Indian republic), scientific policies of the government, the rise of the science museum movement and the establishment of the BITM are intertwined in the powerful narrative of becoming independent from the colonial rule and moving towards increasing self-reliance.

73 See Chapter 2, Section 2 for a discussion on management structure of the NCSM and BITM.

In an essay written in the same special volume, Sthanapati (erstwhile Director of BITM) and Sanyal (curator at the Central Research and Training Laboratory of the NCSM headquarters) explain in an article in the same special issue the important role of the first prime minister of independent India, Jawaharlal Nehru, and other renowned scientists and industrialists in promoting science awareness and education to the population. (Sthanapati and Sanyal, 2009). In fact, the BITM grew out of the imagination of Bidhan Roy, a physician and the then Chief Minister of West Bengal who travelled to Europe and was impressed with the collections of Deutsches Museum in Munich. Once he was back, he expressed the desire to create a similar institution in Kolkata, to preserve its scientific and industrial heritage as the city was a pioneer in the study and research of science, technology and medicine in the 19th century as the capital of British India. The land and building required to house such a structure was provided by one of the leading industrialists of the country, GD Birla, who donated his family's ancestral property to the Council of Scientific and Industrial Research (CSIR) for the development of a science museum, with special focus on industry. As the present director of the museum noted in a personal interview, the only demand of Birla was that the new museum should carry information and displays about industry, alongside stories of science.



No. 264-PMH/56.

New Delhi,
6th February, 1956.

My dear Ghanshyamdasji,

On the 29th January, you gave me a letter in which you told me about your gift of your family house, Birla Park, in Calcutta for the purpose of making it an Industrial Museum. At that time you handed to me also the title deeds of this house, which I passed on to Dr. Thacker.

I must congratulate you and thank you for this generous gift. I am happy also at the use that you have suggested for this house. I think an Industrial Museum will serve a very useful purpose. As Dr. B.C. Roy is the Chairman of the Industrial Museum Committee, I have no doubt that this museum will grow and become one of the special institutions of Calcutta.

As you point out in your letter, your house has been connected in the past with many important events and thus has certain emotional significance. I remember going there so many times to see Gandhiji and to attend meetings of committees.

I would like to perform the opening ceremony of this museum; but you will appreciate that I cannot give a firm assurance at this stage. I do not know where I might be then and what I might be doing.

Thanking you again and with all good wishes,

Yours sincerely,

Jawaharlal Nehru

Shri G.D. Birla,
Birla House,
New Delhi.

Image 3.1: Letter from Jawaharlal Nehru to GD Birla acknowledging the latter's gift of the ancestral house for the purpose of housing an industrial museum (Image courtesy: BITM 50th anniversary special issue, p. 15)

A museum committee was then formed with Dr Roy as the chairman and Amalendu Bose, a patent inspector who had been trained in Kolkata and USA, as the planning officer. It was determined that the planning officer would meet the chairman from time to time during the process of constructing the museum. It was also ascertained by the committee that "The museum must project a sequential story of development of science and technology in specified fields with the help of models, exhibits and actual objects such as engines, machineries and equipment, contribute to the visitors' understanding of the scientific and

technological developments and bring the technology within the grasp and knowledge of the common man." (Sthanapati and Sanyal, 2009). In this planning phase, there was international cooperation and knowledge transfer with two of the most prominent science museums in Europe, Science Museum, London and Deutsches Museum, Munich. W T O'Dea of Science Museum and Karl Bassler of Deutsches Museum visited Kolkata during this time and advised the committee on improving the plan. (Subramanian, 2009)

At this point, it is important for us to pause and reflect upon the content of this new scientific and industrial museum that was being planned. Sthanapati and Sanyal (2009) mention that "The establishment of BITM in 1959 can be considered a consequence of the post-independence National Education Policy, which encouraged popularization of science for sustainable economic growth and social upliftment." It is evident from the discussion above that the narrative of science that was to be promoted in the first public museum of independent India was of technological and scientific optimism, which would in turn help the cause of the nation building process by attracting young people to pursue careers in science as well as create a level of scientific awareness among the entire population. This interest in the need for public awareness of science in independent India can be easily traced back to Nehru and his socialist approach towards governance. In fact, scholars of public communication of science and technology, Brian Wynne and Alan Irwin (1996) point out the role of British socialists and left-wing scientists who argued for the need of creating awareness among citizens. From their discussion on the treatise *Science and the Nation* drafted by the scientific trade union in Britain, Association of Scientific Workers, right after the Second World War, it is clear that there are many similarities between what the Association envisioned as public understanding of science vis-à-vis those ideas coveted by the early nation builders of India: the politicians, scientists, industrialists who all played major roles in determining the scientific and educational policies for the Indian population. Irwin and Wynne note that the three major points from the document are i) knowledge/awareness of science and technology is crucial for creating and sustaining a future workforce, ii) science is an important part of the larger socio-cultural understanding and iii) awareness of science and technology are crucial for the functioning of a modern democracy. In this chapter, we will see that the BITM through its various internal and external activities has always and continues to promote a narrative of science which is

strongly linked to its role in the society. It also has always been active in promoting science education and encouraging young people to pursue careers in science and technology, with a strong focus on the future. This aspect will be discussed in greater detail in the last section of this chapter.

Another strong linkage of ideas of science and public that the planning commission of BITM can share is with the works of JBS Haldane, the British Indian scientist and science popularizer[74], with strong socialist credentials. In the preface to his 1939 work *Science and Everyday Life* he claims that many branches of modern science are easy to follow, even though there exist highly specialized branches of knowledge in the sciences. He goes on to write in the preface that specialized knowledge is required in any kind of work and that both the scientist and the non-scientist should have some understanding of what each does as they are a part of the everyday economy of an individual.

> It is often said that modern science cannot be explained in anything less than a whole volume, and that short articles on it are necessarily worthless. I do not agree. The only subjects which are definitely unsuited are organic chemistry, mathematics, and those branches of science which use a lot of mathematics. These have their own terminology, and one cannot even explain in a thousand words what "Beta-alanylhistidine' or "an almost periodic function" mean, let alone deal with recent work on them. But a great deal of work in other branches of science is quite easy to follow, at least partially […] The ordinary man must know something about various branches of science, for the same reason that the astronomer, even if his eyes are fixed on higher things, must know about boots. The reason is that these matters affect his daily life.[75] (Haldane, 1939)

As we have seen earlier, the BITM was born from the collaborative effort of the central government of India, the state government of West Bengal and the leading industrialists

74 JBS Haldane Avenue is the name of one of the most prominent roads of the city of Kolkata, where the Science City, one of the constituent centres of the National Council of Science Museums, is located.

75 The last part of the quote has also been referred to by Irwin and Wynne (1996) in their preface to the collection *Misunderstanding Science*.

and scientists of post-independence India. There was a collective understanding of this group that it was necessary to promote a culture of science and scientific temper among the population so that they will have greater social awareness of the uses of science. Undoubtedly, the narrative is one of optimism in science to solve larger societal issues ranging from the economic to the personal. However, these early nation-builders felt the need to engage the citizens of India in narrations of science and technology.[76] The next section will look at how and when BITM implemented various methods of engagement between scientists, narratives of science and visitors, who are also various groups of stakeholders in a democracy.

76 One such example can be found in the Indian government's Industrial Policy Resolution of 1956, a document which espouses a strong need to become self-reliant for the social and economic prosperity of multiple sections of the society, where in one part it says 'The Government of India trust that this statement of their Industrial Policy will receive the support of all sections of the people and promote the rapid industrialisation of the country.' (See http://eaindustry.nic.in/handbk/chap001.pdf; last accessed December 2016)

3.2 Quick facts about BITM

Name of gallery	Floor area (in sq. mts.)	No. of exhibits
Transport	350	94
Mock-up coal mine	475	65
Electricity	160	99
Life Science	475	61
Motive power Hall 1	189	41
Motive power Hall 2	189	46
Biotechnology	360	65
Metals	210	51
Physics	255	67
Television	210	29
Popular science	475	47
Mathematics	260	45
Children's gallery	475	43

Staff strength (as of 2013/14): 103[77]

Floor area in square metres: 10351.95

Total number of visitors to BITM (2013/14): 2.28.760[78]

[77] For the current updated list of employees, follow the link: http://www.bitmcal.org/RTI/BITM%20Staff.pdf (last accessed February 2017)

[78] All the above information has been taken from BITM's Activity Report (2013/14). It was the most up-to-date information available at the time when I carried out my fieldwork between June and September 2015.

3.3. Deficit and dialogue: the move towards participation

Recent studies on science museums and centres show that contemporary museums have fully adopted the so called 'participatory turn' (Jasanoff, 2003) for what concerns their engagement with visitors and other stakeholders (Bandelli and Konijn, 2015). Citing the examples of the new policies that selected European museums of science and technology have adopted, Bandelli and Konijn (2015) argue that this approach signals a new shift in the way museums relate to their public. They write: "The one-way, top-down model of communication through exhibitions was replaced by the 'engagement' model: exhibitions and programmes aimed at engaging the public in a debate about the implications of science and research; the focus shifted from the content to the context of science, that is, its social implications." The idea that the museum is an institution which is not only displays artefacts but also provides a space for public dialogue and a democratic discussion on science is a common one in Science and Technology Studies. (see for example, Davies et al, 2008, Cameron and Deslandes, 2011, Bandelli and Konijn, 2015).

The participatory turn in science museums and centres should also be seen in the larger context of science, technology and society debates which evolved with the turn of the millennium. One of the most significant documents to come out in this period is the House of Lords report 'Science and Society' published in 2000[79]. Arguing against the phrase 'public understanding of science' as one that presupposes ignorance on the part of the lay public, the report stresses the need for dialogue and building trust between the scientists and the non-scientists. For what concerns the understanding of science, it includes knowledge of the scientific method (that is, testing a hypothesis with the help of an experiment), awareness of current scientific advances and implications. It is interesting here to consider the understanding of the terms 'science' and 'technology' in the 1985 Bodmer report entitled 'Public Understanding of Science' and published by the Royal

79 See Chapter 3 'Public Understanding of Science' from the 'Science and Society' Report of the House of Lords, 2000. http://www.publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3805.htm#a26 (last accessed December 2016)

Society, of which this was a follow-up. The older report defines science in the following way:

> 'Science' we interpreted broadly to include mathematics, technology, engineering and medicine, and to comprise the systematic investigation of the natural world and the practical application of knowledge derived from such investigation. Though technology and engineering have a sense of direct purpose not usually associated with basic science, there is a continuum of activities that extends from basic through strategic to applied research and development. These activities are all based on common underlying scientific principles. [80] (1985: 7)

The report also mentions in the introduction:

> Science pervades our society. Most of our industry and much of our national prosperity are based on science. In the home as well as at work we use machinery that is the product of this industry. Science affects many, if not most, policy issues of national and international importance. It also affects a wide range of personal activities, from health and diet to holidays and sport. (1985: 7)

The similarities between the early documents of BITM which state the purpose of science and technology, the writings of Haldane and the role of science in society in the Bodmer report can all be seen in a continuum. What is interesting to note is however the tone of the 1985 report, which gave rise to what is called the deficit model, which assumes a superior role of science and the need to educate people in science and technology so that they are made aware of the policy developments of the state and latest research advancements. Can the BITM's activities be studied under the same lens? Did the early science communication practitioners in India also devise a plan to address a deficit in the public's appreciation/understanding of science? Were they interested in engaging in a dialogue with the visitors? If so, when did that start?

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80 The Royal Society. (1985). The Public Understanding of Science. Full text available at: https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/1985/10700.pdf (last accessed December 2016)

3.3.1 Participatory turn at BITM

As early as in 1959, BITM realized the importance of interactivity in science learning and hands-on experience for students. If people were to be told a specialised story, they had to be able to use their sensory faculties for better understanding. The very initial participation was then one which related to design of exhibits. Thus the artifacts were supplemented with a large number of working models with features which would allow visitors to physically interact with models and participate in the meaning-making. Early experiments were also carried out with immersive experience, as a "mock-up coal mine" came up in the museum in 1983, which offered visitors the possibility to interact inside a replica of a real coal mine. With the turn of the new millennium it was felt that while the older galleries were object and replica based displays, the new galleries had to be more interactive with focus on group learning, specifically targeted towards student groups.

Focus on creating a science-conscious population for the future through multi-pronged approach has always been strong in the BITM's plan of action to bring science and technology to as many sections of the society. Students have been the greatest beneficiaries of this strong objective. As Sthanapati and Sanyal (2009) mention "The potential of museums as provider of non-formal science education was realized even by early science museums. In India, the BITM is the pioneer in non-formal science education to students through museum activities." The museum's activities have not only reached out to students but also other stakeholders who form the larger school community. In the essay by Sthanapati and Sanyal, the authors also mention instances of teachers requesting help in creating educational kits or demonstration lectures which could be used to supplement their own classroom work. As they recount, one of the very first examples of stakeholder involvement with the museum was in 1965, when a school teacher approached the museum to create a model of the solar system, thus also giving rise to the science demonstration lectures (SDLs) targeted towards students. Students were also proactive as requests for hands-on training also came from them, giving rise to specialised educational camps. In their own words: "An important aspect of BITM's educational programmes was that they

were not imported from the west and imposed upon local students; instead, the demand came from the local student-teacher community." This is also a very interesting example of early engagement of various groups of stakeholders in the society, coming together for the cause of public participation in the dissemination of scientific knowledge. The museum not only had its own programme to showcase the narrative of scientific and technological progress; it was also open to ideas coming from the public (here it is also important to mention that school teachers, while they are visitors/public, also belong to a special group of experts in their own fields), always ready to co-opt them into its own set of activities. Thus, the museum superseded its role as a provider of a specialised service. It worked in tandem with the society to address the needs and demands at large. It is thus only befitting when Saroj Ghose writes in the same volume commemorating 50 years of BITM:

> In retrospect I look back at the golden days of my life in BITM, during 1965-70, when mobile science exhibition buses started rolling on the road, science demonstration lectures were introduced to supplement formal science education in schools, experimental district science centres started functioning in Purulia, Midnapore, Digha and Raigunj, science seminars and science fairs came out of the shell of Calcutta to spread at the district and state levels. These events were the forerunners of a nationwide science museum movement, and in the days ahead BITM was aptly called the 'mother museum' in India. (Ghose, 2009)

Terms such as 'participation', 'engagement' and 'dialogue' have become increasingly important in museum studies vocabulary[81]. The phrases have gained currency and popularity in the last decade or so, especially, following the publication of the 2000 House of Lords report, culminating with the publication of Nina Simon's seminal work *The Participatory Museum* (2010) which discusses multi-modal methods of visitor participation, through design of exhibits, enhancing collaborative efforts between various stakeholders to ensure better engagement and dialogue. Based on the recollections of Sthanapati and Sanyal (2009) and Ghose (2009) in the special issue, it can be said that museum practitioners of BITM were already experimenting with stakeholder participation.

[81] In the fourth chapter, methods of engagement and participation in museums will be taken up as one of the discussion points.

Did this participation extend to the galleries and the public engagement programmes? In the next section, we will take a look at the galleries of the BITM. First, public opinion on the galleries will be discussed using data collected by the museum officials. Second, we will move inside the gallery space and take a close look at two of them.

3.4 BITM's galleries: public opinion

The BITM, at the time of its establishment, had galleries on electricity, petroleum, nuclear physics, metallurgy, optics, electronics and television. The choice of themes for the galleries evidently reflected the science and educational policies that the then government had formulated for encouraging social upliftment as well as economic sustainability (Sthanapati and Sanyal, 2013). During my visits to the BITM, I carried out interviews with curators, educators and explainers. One of the interviews was with the Public Relations Officer of the museum. While mentioning that the present footfall at the museums, especially of student visitors, was good, he spoke at some length about the need to ensure a better-designed website to attract more public. He also indicated that school children are a strong focus of the BITM and form the core visitor group, as is evident from some of the galleries which were set up to function as laboratories. The general public on the other hand is interested in informal science learning present in galleries like 'Popular Science'. Alongside the time for a discussion, Seal also shared a questionnaire with 91 responses which were collected from the visitors in early 2014. The questions in it pertain to the motivation of the visit, the experience during the visit and feedback related to its facilities. In the paragraphs below some of the questions and their responses will be analysed in detail to provide a picture about visitor's reception and reactions towards BITM's offerings. It is also important to remember here that many of these respondents do not form a part of the core group of visitors (the students), and hence it is not representative data of all visitors.

Upon receiving the 91 responses, first all the data was transferred to MS Excel. After that to arrive at the frequency of an option and the percentage of choices, the software STATA was used.

One of the entries in the questionnaire asks from which medium did the visitors come to know about the museum. The options included a wide variety such as radio, television, newspaper, billboards and hoardings, buses, bus shelters, brochures, magazines, museum website and the Internet. All these options were coded from 1 to 10 respectively. Respondents could choose multiple options or select none. In this case the total number of responses was greater than 91.

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. tab Q5
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Q5	Freq.	Percent	Cum.
1	1	1.01	1.01
2	4	4.04	5.05
3	17	17.17	22.22
4	8	8.08	30.30
5	4	4.04	34.34
6	4	4.04	38.38
7	12	12.12	50.51
8	12	12.12	62.63
9	21	21.21	83.84
10	16	16.16	100.00
Total	99	100.00	

Figure 3.1: Responses to "What medium did you hear about the museum from?"

As evident from the table above, two of the top three medium through which visitors came to know about the museum involve the Internet and World Wide Web, more specifically. This, apart from confirming previous researches on the efficacy of websites in communicating the goals and activities of institutions (Marty, 2007) also points out the need to pay attention to constantly upgrading the website in order to attract more visitors. It is also interesting to note that the role of traditional print media, newspapers, brochures and magazines continue to be significant in advertising the museum. However, this can also be understood as the BITM sends out a number of communication related to new programmes and activities to schools and undergraduate universities. The national and

regional level science competitions are advertised in newspapers. While the respondents in this survey did not include the students, it did include school groups led by teachers, who must have had access to the printed material.

One of the questions asked the respondents the reasons for visiting the museum. Respondents had to choose between eight options, including 'interest in science/technology', 'to bring children', 'entertainment/fun', 'to bring guests who are visiting', 'educational purposes', 'sightseeing' and 'to spend a day in Kolkata'. They could choose multiple options. These options were coded as numbers 1 to 8 respectively, and the frequency of each option was observed as follows:

Q8	Freq.	Percent	Cum.
1	49	31.41	31.41
2	23	14.74	46.15
3	31	19.87	66.03
4	3	1.92	67.95
5	35	22.44	90.38
6	8	5.13	95.51
7	1	0.64	96.15
8	6	3.85	100.00
Total	156	100.00	

Figure 3.2: Responses to “Why did you visit the museum?”

As it can be observed here, many among the 91 respondents had more than one answer as n=156 in this figure. The two most popular options were, unsurprisingly, 'interest in science/technology' and 'educational purposes' which combined reflected 54% of the choices. Clearly BITM's role as a centre for informal science education and learning is highlighted by the frequency of these two options. Two other options also deserve attention as visiting the museum 'to bring children' and for 'entertainment/fun' were selected by a significant number of respondents. Interestingly, the least popular option was 'sightseeing' which was selected by only one respondent. In interviews with multiple officials at the museum, they mentioned that BITM's focus was on engaging with young visitors and to offer informal science training to school children and young adults. (For tourists who would be interested in sightseeing and casual visitors with interest in popular science, the

option was Science City instead, which is modeled as a science park. Science City, Kolkata is also a unit under NCSM, but unlike others, it generates its own revenues for its running costs. It has both indoor and outdoor (mostly hands-on) exhibits on various topics of science and technology.

However, upon asking if they were visiting to see specific galleries and exhibitions, most respondents (close to 63%) said no. Among the ones who were visiting to see specific galleries, the most popular answer was the 'children's gallery', thereby confirming that some visitors indeed were motivated to come to the museum to bring their children. In fact, a large section of the visitors among the respondents came to the BITM with a child or young adult, as is evident from responses to the question “How many persons, including yourself, are in your immediate party?”. The options were 'one adult', 'one adult and one child', 'more than one adult and one child', 'one adult and more than one child', 'multiple adults' and 'multiple adults and children'. These responses were also coded as 1 to 6 respectively. For no response, the code 99 was used.

Q30	Freq.	Percent	Cum.
1	5	5.49	5.49
2	2	2.20	7.69
3	26	28.57	36.26
4	2	2.20	38.46
5	35	38.46	76.92
6	18	19.78	96.70
99	3	3.30	100.00
Total	91	100.00	

Figure 3.3: Responses to composition of the visiting group

The above figure shows that out of the 88 responses from the 91 respondents (three respondents did not answer), 48 people were there with at least one child. 18 respondents were there with multiple children, and at least some of these could be identified as school groups. Another 26 of the respondents came in groups with one child, suggesting that these

were family outings. The most surprising data from this figure is that the majority of the respondents chose option 5 or 'multiple adults'. While BITM is a museum for young people, the officials also reiterated that they wanted people from all sections of the society to utilise the services and to engage in informal science learning. And this data seems to suggest that the museum does get a lot of curious adults who are interested in knowing more about science and technology. However this issue needs to be studied more and in fact if the BITM is able to attract more visitors from the adult lay public with interest in science and technology, it would be able to position itself as one of the must visit spaces of the city, which would in turn serve their purpose of reaching out to as many sections of the society as possible.

The visitors were then asked to indicate the permanent galleries, exhibitions and special shows/demonstrations that they liked the best. They could also choose more than one option. This resulted in n=134, as there were multiple respondents with several favourites. All the responses were then coded (according to the names of the galleries/exhibits/special shows) and run on stata to arrive at the table below. It should be noted here that 'No Answer' was coded as one of the responses in cases where the visitors did not indicate any preference.

Q26	Freq.	Percent	Cum.
3D	2	1.49	1.49
A	11	8.21	9.70
CG	30	22.39	32.09
CM	1	0.75	32.84
E	2	1.49	34.33
IH	3	2.24	36.57
KZ	1	0.75	37.31
LS	3	2.24	39.55
M	1	0.75	40.30
MG	13	9.70	50.00
NA	12	8.96	58.96
PG	5	3.73	62.69
PS	23	17.16	79.85
PSG	3	2.24	82.09
SG	1	0.75	82.84
SS	4	2.99	85.82
T	12	8.96	94.78
TV	7	5.22	100.00
Total	134	100.00	

Figure 3.4: Responses to “Which gallery did you like the most?”

Unsurprisingly, the top two choices were 'Children's Gallery' (CG) and 'Popular Science' (PS) with 22% and 17% of the respondents selecting them respectively. As it has been discussed in the earlier paragraphs, many visitors come to the BITM with their children and the Children's Gallery is an obvious choice for them to spend some time. During my period as a participant observer, I also happened to meet young parents who chose to spend their leisure hours with their children at the museum, and specifically wanted to visit this gallery. Opened in 2012, the gallery provides children with a carefully designed space where they can learn and play at the same time. Popular Science is the other permanent exhibition which draws significant attention. Based on the hands-on exhibits made popular by the success of Exploratorium, this gallery has a large number of exhibits on basic scientific principles which are presented as questions/riddles alongside physical demonstrations. It would also be interesting to note here that the Children's gallery and the Popular Science gallery are both located in the building which is closest to the entrance to the museum, thereby making them most easily accessible to casual visitors.

The other two galleries which have very high approval among visitors are the 'Mathematics Gallery' (MG) and 'Transport' (T), two of the galleries which also focus on the Indian scientific and technical heritage. The transport gallery (chosen by almost 9% of the respondents) hosts historical artifacts as well as models of various modes of transportation starting from the invention of wheels to supersonic jet engines. Here the visitor also finds stories from Indian history about the early boats that criss-crossed the innumerable Indian rivers as well as those about railways and colonial history. The Mathematics gallery which was liked the most by almost 10% of the respondents is also one of the new spaces created specifically with students in mind. It has been conceptualised by the museum administrators as an educational lab (personal interview with the Director of BITM), especially because Mathematics is perceived as one of the most fundamental disciplines in science and the focus is on motivating young people to do STEM studies. Indian contribution to mathematics is highlighted in some of the exhibits in this gallery.

Two galleries are conspicuous in their absence from the list: biotechnology and motive power. It would be interesting to study why they were not preferred by any of the

respondents. Two other responses deserve to be highlighted here as they show two opposite sides of the visitor satisfaction spectrum. About 8% respondents said that they liked all the galleries and shows ('A') and another 9% did not answer ('NA') the question. However, for what concerns the overall satisfaction and value for admission to the museum visits, the answers were extremely positive, as is evident from the responses to "Rate the value for admission between 10 and 1 as they apply to your visit to the museum today. Use 10 to indicate excellent and 1 to indicate poor." The frequency of each number from 1 to 10 was calculated. In case of no answer, the placeholder '99' was used. Results are shown below:

Q12	Freq.	Percent	Cum.
1	2	2.20	2.20
10	6	6.59	8.79
2	3	3.30	12.09
3	2	2.20	14.29
4	1	1.10	15.38
5	2	2.20	17.58
6	8	8.79	26.37
7	13	14.29	40.66
8	21	23.08	63.74
9	14	15.38	79.12
99	19	20.88	100.00
Total	91	100.00	

Figure 3.5: Responses to rating the value for admission

As it is evident from the figure, the satisfaction of visitors was consistently high with 8 and 9 being the two most frequent ratings. In fact, close to 29% people rated the value for admission with a 9 and another 22% gave an 8. Yet another 12% rated the experience as a 10. This means that an overwhelming majority of people, around 60%, was very satisfied with the experience at the museum.

It would also be interesting to recall here the data from the first chapter, where public opinion on entrance fees to Indian museums is that they are quite low. So, does it mean much if visitors say that they have had great satisfaction for the value of the price of admission? In fact, the questionnaire carried questions related to multiple parameters to

judge various aspects of the museum: its management, galleries, overall presentation and staff. This question was chosen to be highlighted here because it encapsulates the feedback gathered from all the above-mentioned queries. In the next section, the permanent exhibits will be dealt with in greater detail to understand the content of the science which is being communicated.

3.5 Select permanent galleries of BITM: science centre in the science museum

> Meanwhile, in recent years the great national museums have been complemented by a growing number of "science centres". A science centre is distinguished from a science museum by having exhibits and activities but no collections. The existing United Kingdom science centres, numbering around 40, are highly diverse; typically they are small, and local or regional in origin and support, with a mission focused on interesting and enthusing children. (House of Lords Report, 2000, Chapter 3[82])

The 2000 House of Lords report which sparked discussions on the 'dialogue' model in science communication literature has a section on museums (in Chapter 3 of the report). In the above quoted extract, it talks about the rise of science centres as institutions for science popularisation, especially for children. The growth of science centres is however not as recent as the report claims; even though it must be added that it talks primarily about incorporating characteristics of science centres inside the science museum space. The Exploratorium experiment of Frank Oppenheimer in 1969 and the opening of Ontario Science Center in the same year signalled a new kind of institution where hands-on exhibits prevailed over collections, thereby broadening the definition of a science museum. (Hein, 2000) We see the reflection of this change also in the transforming definition of museum in the ICOM statutes. In 1961, the definition of a museum included:

[82] See text of Chapter 3 here: https://www.publications.parliament.uk/pa/ld199900/ldselect/ldsctech/38/3805.htm#a30 (Last accessed December 2016).

1. exhibition galleries permanently maintained by public libraries and collections of archives, 2. historical monuments and parts of historical monuments or their dependencies, such as cathedral treasuries, historical, archaeological and natural sites, which are officially open to the public, 3. botanical and zoological gardens, aquaria, vivaria, and other institutions which display living specimens, 4. natural reserves.[83] However, a decade later, in 1974, there was a fifth point added: science centers and planetariums.

The discussion on whether the science museum is distinctly different from the science centre is one that is worth revisiting before we move to the discussion on the permanent galleries of the BITM, which exhibit features of a mixed museum-- of both science museums and centres.

In the introduction to his widely popular[84] edited volume *Museums and the Public Understanding of Science* (1992), British museologist John Durant, who later would also be one of the members of the House of Lords Select Committee of Science and Technology from 1999-2000 and helped drafting and editing the 'Science and Society' policy report, explained the difference between science museums and centres in the following words:

> Typically, a science centre interactive is a device that embodies an elementary scientific or technological principle, and visitors are encouraged to 'play' with this device, usually with a minimum of textual or other guidance, in order to 'discover' the principles for themselves. A science museum exhibition is a scripted 'story' about an entire area of science or technology, told with the assistance of many different objects, interactives, captions, and (increasingly) audio-visual and electronic media...we might say that a science centre presents a smorgasbord of bit-sized chunks of science, whereas a science museum presents a menu of more or less carefully concocted scientific dishes." (Durant 1992, 8)

83 ICOM. Development of the museum definition according to ICOM statutes (2007-1946), http://archives.icom.museum/hist_def_eng.html (last accessed December 2016)

84 It was reprinted several times.

Through this description, Durant lays down the distinctions between a museum and a centre in clear terms. The museum is a space of telling a story with objects and audio-visual aids, focusing on a specific narrative/topic. The centre on the other hand is a space for science learning with the help of stand-alone exhibits. This distinction however has been slowly diminishing, as exclaimed by Walter Staveloz, Director of International Relations at the Association of Science-Technology Centers in Washington DC.[85] In a personal interview, Staveloz elaborated upon the need to reduce the differences between science museums and centres, and said that many institutions are already combining the features of both. Science centres are increasingly moving away from the push-button environment and embracing contextual storytelling methods and creating multidisciplinary exhibits, while museums are incorporating hands-on educational activities which complement their galleries.[86] On discussing the same issue with Saroj Ghose, however, the response was more inclined towards an explanation based on availability of resources. Ghose was quick to point out that while in the initial years of planning the European style of science museum was perceived to be the kind of institution that would be useful for narrating the story of Indian scientific heritage. However, the focus as determined by the governmental experts was on science education and informal training in contemporary science and technology. Hence, once the government task force was formed in the 70s to facilitate the creation of more museums, the decision was to focus on institutions which would provide hands-on training.[87] Ghose also indicated that, in India, due to the strong developmental agenda pursued by the government, and the many social problems that needed to be addressed, it was not feasible to create separate science museums and centres with their specific goals. Furthermore, as Sthanapati and Sanyal (2009) mentioned, "artifacts could not be collected

85 The website of the Association of Science-Technology Centres can be found here: http://www.astc.org/ (last accessed February 2017)

86 This is true especially in many European science museums. The one museum which I followed extensively throughout the course of the PhD, the Museo della Scienza e della Tecnologia in Milan, has a corresponding educational laboratory specifically targeted towards school students, for every permanent gallery. The Museo also has specific spaces like the 'Tinkering Lab' which encourage further hands-on training. However, it strongly retains its identity as a history of science and technology museum with its extensive collections of objects.

87 This point has been discussed at some length in the previous chapter.

in an organized manner because such objects were not abundant in India in 1950s". Emdadul Islam, the present Director was quick to point out in a personal interview that the availability of skilled craftsmen was crucial at this early stage for fabricating working models of scientific objects.

In the recent years, however, the museum has features of both a traditional science museum and centre, as in, there are galleries which have objects and working models which demonstrate a certain narrative of scientific and technological development, and in other cases, a gallery functions as a laboratory for school students to visit and recapitulate what they have learnt in their schools. In this section, I will discuss two of the permanent galleries at the BITM: one which exhibits the classic features of a science museum with a specific narrative on a topic aided by objects and models, and the other which promotes science learning and hands-on training (it narrates a story as well, but without objects). The first one is the Transportation gallery and the second is the Mathematics gallery. Both are relatively new additions to the permanent galleries of the museum.

3.5.1. Transport gallery

To begin with, let us quickly consider the description that is available on the website, which as literature on museum studies has shown us, is the first point of contact of any institution, including museums.

> A thematic gallery on Transport was thrown open to public on the occasion of the year-long celebration of the Pre-Golden Jubilee year of this institution during 2008 – 09. Spread over an area of 500 sq.m. with approximately 50 models and exhibits, the gallery portrays the development of transport system from the 'Wheel' to the 'Supersonic Jet Engines' of the modern time through artifacts, models and interactive exhibits in thirteen specified sections. This gallery as a whole presents an opportunity to the visitors to see how the development of transport system in water, on land and in air has added new dimensions to the human life. A 1926 Rolls

> Royce Car and the Fiat Tipo used by the eminent scientist Sir Jagadish Chandra Bose are the star attractions of this gallery.[88]

From this description, the following things become apparent: that it is an object-heavy gallery (with both original artifacts and working models), that it traces a progressive narrative of how transportation has evolved and aided human life (the story starts with mankind's tryst with the wheel and goes on to talk about supersonic jet engines) and that multiple modes of transportation are on display. From the field notes that I collected during my visit to the gallery, I came across a fourth feature, the strong focus on Indian heritage in transportation. This includes early models of various kinds of boats which sailed on the rivers and seas of India (including those which were used in combat from the first millennium), the colonial heritage of railways with miniature and life-size models of steam locomotives, and the recent developments in the construction of metro railway, complete with plans of new cities which will benefit from this infrastructure. As is evident from the description, this is also a gallery which displays some of the museum's collection of artifacts, with the pride of place going to the car driven by one of India's most famous scientists, Jagadish Chandra Bose.

88 See page http://www.bitmcal.org/galleries_transport.php (last accessed December 2016).

Image 3.2: Miniature replicas of locomotives from the 19th century at the BITM Transport Gallery (Image courtesy: BITM)

3.5.2. Mathematics gallery

To be able to provide a sampling of the widely divergent styles of the galleries, it is necessary to look into the Mathematics Gallery. Once again, we start with the description that has been made available on the website:

> The new gallery on 'Mathematics' at BITM (inaugurated on May 8, 2010) is an attempt to present mathematical concepts in simple manner and provide enjoyable learning experiences through models, working exhibits in order to create interest in the subject among the young generation so that they are able to pursue higher studies in pure sciences with greater confidence.
>
> Supported mostly by interactive exhibits & graphical illustrations, the gallery is a living mathematics lab which offers opportunity to experiment, solve problems and

> appreciate the beauty of mathematics. Spread over an area of 300 sq.m with about 54 exhibits, the thematic canvas of the gallery includes a brief history of numbers, number theory, positional number systems highlighting India's seminal contribution in their development, basic arithmetical operations, geometry of plane and curved surfaces, solid geometry & conics, mathematical functions, probability & statistics, the basic ideas of calculus, mathematics in nature, and a variety of mathematical kits and brain-teasers for kids.
>
> A 'Math Demo Corner' with facilities for conducting a class session on mathematics by the accompanying school teachers, and a 'Children's Activity Area' add to the attraction of the gallery.[89]

The Indian heritage in Mathematics is widely known to historians of science. The fact that the country is now an Information Technology (IT) giant is also a result of a strong curricular thrust in Mathematics, evident in school syllabi. And yet, many students continue to face problems in understanding the basic concepts. As Subhasis Das, Curator at the BITM writes (2014): "The general perception is that mathematics is very abstract, hard to visualize and difficult to connect to physical realities." Given the focus on math and the persistent difficulty that students face in confronting the discipline, the museum, as the Director confirmed in our interview, decided to open this new gallery where it would be possible for young learners to visualise mathematical principles using models and engaging in hands-on activities. Thus, while we find informative exhibits of ancient Indian mathematics, maximum space is devoted to providing detailed descriptions of algebraic, geometric and trigonometric principles which are supposed to aid students while they learn these same topics in their classrooms. In fact, the gallery also had a full-fledged classroom-like demonstration space (with a digital smartboard) where discussions on Vedic and curricular mathematics take place. (Das, 2014). Das further explains that the gallery is now used by many school teachers as a laboratory, or an 'extended practical classroom'. The

89 The webpage of the Maths gallery is available at: http://www.bitmcal.org/galleries_Math.php (last accessed December 2016)

BITM in fact is helping a few other educational institutions to set up similar laboratories upon the demand rising from the teachers' community.

Image 3.3: Science explainer with school students around the Famous Mathematicians exhibit at the gallery (Image courtesy: BITM)

Image 3.4: Principles of school curriculum Mathematics explained through hands-on exhibits. In the foreground, we can see applications of Trigonometry. In the background, algebra. As mentioned earlier, this gallery functions as a lab for school students. (Image courtesy: BITM)

3.6 Engagement and outreach activities of the BITM

A comprehensive understanding of BITM necessitates an analysis of the museum's outreach activities and the reasons behind designing extensive outreach programmes that the museum now boasts of. To begin with, let us consider the following extracts taken from the Museum Director, Emdadul Islam's essay of 2013:

> Science museums in India are relatively recent developments compared to their peers in the western world, and are almost as young as the country's political freedom is. However, over the last 60 years or so of their existence, Indian science museums and science centres have emerged as dynamic social institutions ready to

> change with the demands of their time and in response to the changing needs and aspirations of their respective societies.
>
> Broadly, activities of science museums/centres in India have evolved over the years to achieve two major institutional objectives: (i) taking science to people, and (ii) making people for science. And the means to achieving these objectives are also generally of two types: (i) exhibits and exhibitions, and (ii) science interpretation activities and educational programs. (Islam 2013, 439)

Recalling once again the discourse on public participation in scientific institutions, we can see here that Indian science museums and centres were developed following a strong democratic narrative of development which Indians could partake in collectively. Islam mentions that the museums and centres have emerged as 'dynamic social institutions' and this is an important point for further discussions, especially in the literature on science communication and public understanding of science. To view a science institution as a social institution is a very important step forward in not only reaching out to many people, but also making the people in charge of disseminating scientific information, more approachable and accountable to the public.[90] This reach is evident from the range of activities that BITM (and indeed all other museums and centres under NCSM) possesses in its resume. To further understand how much public participation exists in deciding the content of some of these activities, I carried out a personal interview with the chief education officer of the BITM, Dilip Ghosh. While talking about the extension activities in general, and the Science Demonstration Lectures (SDLs) in particular, he explained:

> *We have a number of tie-ups with schools for our extension activities. Schools can choose to be institutional members of our museum. This allows them to also bring as many students for a visit on a single day. The science demonstration lectures that we carry out everyday at specific hours are also free for members. Lectures are carried out by science communicators and they are based on existing school*

90 The issue of accountability of public institutions towards its many stakeholders (including citizens of the country) is discussed at length in the non-profit management literature. Some of these discussions have been highlighted in the previous chapter.

curriculum. Schools can also choose the topic on which the lecture is to be delivered. These lectures are also a good place for students to see the experiments that they study about in their books.

In the next sections, we will delve deep into two specific activities of the BITM, one directed towards the rural population and the other for students in urban areas, thereby trying to achieve a broad sample of people who the BITM is reaching out to.

3.6.1 Mobile science exhibitions and BITM's pioneering role

In the previous chapter, the rationale of NCSM's Mobile Science Exhibitions has been discussed in connection with the promotion of scientific temper among rural masses. The MSEs were designed to reach out to the vast majority of the rural population who did not and still many of whom do not have access to education, let alone specialized science education. Already in the 60s, this cause was taken up in all earnest to ensure that scientific awareness is communicated to rural people. Sthanapati and Sanyal (2009) say that "to plan and design a suitable mobile science exhibition for rural India, a team of scientists and engineers headed by Dr Saroj Ghose was set up which studied traveling exhibitions in the US and also UNESCO traveling exhibitions". The decision was also taken at this time to standardise the number of exhibits, the size of exhibition cabinets, so as to ensure efficiency in delivery. The first exhibition that the BITM developed (and which was rolled out in 1965) was entitled 'Our familiar electricity', and consisted of explanatory exhibits like 'How does an electric lamp glow?' or 'How does a fan rotate?' The exhibition also had samples of an interactive phone booth (a novelty in India for those times), radio receivers and domestic wiring. This very first exhibition was hosted, not in a Museobus, as has been common from almost the beginning till date, but in a school auditorium in the southern outskirts of Calcutta. Inaugurated by the then Chief Minister of West Bengal, Prafulla Chandra Sen, it attracted curious visitors as well as media attention. This success of the exhibition also strengthened the resolve of the museum professionals to make it accessible to rural areas in the state and subsequently in the entire country. The second exhibition

which was planned on 'Science of Motion' thus opened in a more remote area, 50 kilometres away from the city. However, it was soon found out that while the demand for these mobile exhibitions was very high in the rural areas, many remote schools did not have the facilities to host one. Hence the decision was made to carry these exhibitions in a bus. In 1966, BITM's own museobus with 24 exhibits on 'Transformation of Energy' rolled out. The bus carried, alongside the exhibits, an explainer, a technician and a driver.

The MSEs today form a major part of the activity of BITM's satellite units. In the eastern zone, by 2009 there were eight MSEs managed by the various centres, namely: 'Laws of Motion' and 'Fun Science' (BITM), 'Energy' (Patna), 'Global Changes' (Regional Science Centre, Bhubaneshwar), 'Emerging Technology' (District Science Centre, Purulia), 'Planet we live in' (DSC, Bardhaman), Mathematics (NBSC, Siliguri) and 'Popular Science' (DSC, Dhenkanal). These buses criss-cross the length and breadth of the eastern states, reaching out to about 400 sites each year[91], as of 2009. (Sthanapati and Sanyal, 2009). As we can notice, there is a wide range of topics being covered in these exhibitions. Rustagi (2013) notes that: "Information related to health and hygiene, environment, sanitation, scientific agriculture practices, space applications for rural benefits, water, energy, IT, etc. are showcased to the rural audience at their very doorsteps through these buses."

The connection between the nation building process and the MSEs requires some elaboration in this context. The reason why Saroj Ghose and his colleagues at the BITM were keen on reaching out to as many sections of the society, and especially create specific programmes targeted for the rural population can be traced back to the socialist origins of the Indian state. Much of the Indian population lived and continues to live in villages, where people do not have access to the level of education available in the cities. Talking about this imbalance in dissemination of scientific knowledge, Rustagi points out, "Removal of poverty and attainment of economic self-reliance and prosperity of the nation can be achieved by reducing this disparity." The other reason why such attention has been

91 This count is related to the eastern Indian states only. The national level count is about 1200 sites as per Rustagi (2013). He writes that the 22 museobuses travel, on a yearly average, 60000 kilometres of rural India and reach out to about 3 million people.

paid to reach out to the corners of the country is the promotion of scientific temper[92] which is intrinsically tied to the notion of reaping demographic dividend[93]. As India has a large young population, a huge part of which resides in rural areas, public institutions have to ensure that they reach out to as many people, especially the youth, and promote a narrative of growth and development with the use of science and technology, and more importantly promote a scientific way of thinking. As it was apparent from many of the interviews, that I carried out during my period in Kolkata, combatting superstitious beliefs and addressing social issues have been two important causes that the NCSM and its constituent museums have taken up. For a country with a large population in the working age, it is clear why the science policies are geared towards not just science education but promotion of logical, rational thinking and a scientific approach towards problem solving. Demographic dividend can be reaped only when the disparity of knowledge between city dwellers and rural population is lessened, when all communities have access to scientific knowledge and the willingness to think scientifically to uplift themselves as well as contribute to the society. Quoting Nehru, Manekar (2013) wrote: "In India, our first Prime Minister, Pandit Jawaharlal Nehru, a visionary, strongly believed that 'It is science and science alone that could solve the problems of hunger and poverty, of insanitation and illiteracy, of superstitions, deadening customs and traditions, of vast resources running into waste, and of a rich country inhabited by starving people'." These are the reasons which were influential in the formation of the Innovation Hubs and led to the rise of the concept of "grassroots innovation".

92 Scientific temper, a phrase coined by Nehru as mentioned in the Introduction, is an important part of the rhetoric of NCSM. It combines scientific attitude with the use of scientific approach and thinking. See previous chapter for the extended discussion.

93 Another phrase which finds mention in the NCSM's annual reports. See previous chapter for discussion on this issue.

3.6.2 Approaching grassroots innovation through the BITM Innovation Hub

Anil Gupta, a professor at the Indian Institute of Management, Ahmedabad is one of the main proponents of the concept of 'grassroots innovation' which discusses the need to harness rural people's skills and technology. He writes:

> We should not discount completely the merit of providing certain goods and services to the people at the bottom of the economic pyramid, but the fact remains that poor people are not at the bottom of the knowledge, ethical, or innovation pyramids. Unless we build on the resources in which poor people are rich, the development process will not be dignified and a mutually respectful and learning culture will not be reinforced in society. (Gupta, 2013)[94]

While in Science and Technology Studies, innovation has been a key concept, the interest in grassroots innovation is recent. Shobita Parthasarathy, professor at the Ford School of Public Policy, University of Michigan, has been conducting work on this issue recently, and she defines it, on her website, as "low-tech, small-scale, and low-cost technologies developed by average, invariably resource-poor, citizens".[95] We might choose to debate about the understanding of the citizen which comes through in the two definitions, with one where the citizen has more agency than the other; however, the crucial point here is the creation of technology with limited resources. The NCSM and the BITM which are engaged in promoting scientific temper to harness the potential of young India are very active on this issue of promoting 'grassroots innovation' as well.

In a conversation with the curator of the Innovation Hub at BITM, he mentioned the centrality of the concept of 'grassroots innovation' to the governmental policies on this issue. To tap into the talents of India's billion plus population, many who are young and

94 Gupta, AK. (2013). Tapping the entrepreneurial potential of grassroots innovation. *Stanford Social Innovation Review* (Summer 2013). Retrieved from https://ssir.org/articles/entry/tapping_the_entrepreneurial_potential_of_grassroots_innovation (last accessed February 2017).

95 The link to Professor Parthsarathy's webpage is available here: http://shobitap.org/grassroots-innovation/ (last accessed December 2016)

are of working age, are resourceful and yet resource-poor, it is important to address innovation as something that everyone is capable of achieving; and not as a top-down concept where only the government, research institutes and big corporations are in charge of providing technological solutions to the society. He further mentioned in the interview that the discussion on innovation and how to promote it has gained a lot of momentum in the recent years, as is evident also from President Pratibha Patil officially announcing the decade of 2010-2020 as the Indian decade of innovation. A number of initiatives have sprung up as a response to this call since 2010. The National Innovation Council was formed as a think tank to chalk out plans regarding how to develop centres around India to promote innovation, as a part of this decade-long vision. The council selected some of NCSM's science centres (alongside other scientific institutions) for this task. As the science centres already promote public understanding of science and technology, they were felt to be optimal for popularizing the concept of innovation among visitors and the larger civil society. The NCSM took up the task of setting up specific spaces or 'Innovation Hubs' dedicated for this purpose from 2012. The BITM hub was opened to the public in August 2013. Furthermore, he explained the target group for the Hub and the main motivations behind opening such a facility.

The innovation hub is open to school students (Classes 6 to 12) and college (undergraduate) level students. Different branches of science and technology are covered in sessions (between one and two hours) of about 30 students monitored by explainers, who are also technical officers employed at the museum. The topics include, and are not limited to, mechanical engineering, robotics and electronics. The philosophy behind the activities at the innovation hub is 'to be your own workforce'. If we can develop students who not only come up with ideas but also execute them, it is going to be beneficial for the country in general. The hub is designed to support and channelize the creativity of the students, by providing them with raw materials (for making models) and also mentorships (curators and technical officers as mentors). We expose them to the research and development infrastructure that is available, so that they can also make informed choices about their careers. We also encourage them to work in groups and come up with new ideas related to the problems that ail the society and how to solve them.

The space is accessible to those visitors who have membership. Two types of membership are available at this point: institutional and individual. Educational institutions like schools and undergraduate colleges can register as institutional members, and have access to structured sessions with science explainers who are technical officers at the museum. Students from high school and undergraduate colleges can also avail of individual memberships, with fee waivers made available to those from the underprivileged background. In the session that I happened to sit through as an observer, it was one with an institutional member, Mahadevi Birla School, and its students from senior years. The session I attended was one with about ten girl students, divided into two groups of five, who were learning about robotics.

To have a better understanding of how this space works and how the participants respond to a specific type of scientific discourse (in this case, innovation), I visited the Hub on the 31st of July, 2015 between 3pm to 5pm. One of the technical officers was in charge of monitoring the session and explaining the process of building a robotic model of a bumper car. (pic here) The car had already been assembled by the students in a previous session. So, on that day, they were going to try and use the programming software to create commands to move the car. A little after 3pm, around 10 participants, girl students from Class 10 (senior school) entered the Hub and seated themselves in the room where they were supposed to conduct the experiment.[96] The technical officer was explaining the task to them, interestingly, in Hindi. He asked the students to try and create a square or circular path for the car to follow. He also showed them how to use the software and talked about computer-aided design in general. It was now time for the girls to give it a try. All five members were participating equally and discussing how to perform the task in the best possible way. In the meanwhile, the mentor had moved to the other group. A little after half an hour of effort, the group under observation managed to complete the task. The mentor was happy; he advised them to reduce the time taken by the car to make its movements, and also to create a square path. He was evidently interested in ensuring that the students push their own limits and also get as much practice with the software as

96 I was sitting at one of the tables with five participants (as a participant observer) and introduced myself when they came in.

possible. While they were working on improving the task, I managed to have a quick chat with them. They revealed that this activity is not a part of their school curriculum, as in they are not graded for it. It was impressive to meet these young girls who at the end of their school week was prepared to come and learn more about science, technology and innovation.

The teacher who had accompanied them, a high school chemistry instructor, also spoke at length with me about her experience in collaborating with the museum and this newly opened Hub. She mentioned that the educational activities related to scientific awareness on issues like health and environment are closely aligned to the outreach activities of the museum. The multiple science seminars, fairs, popular lectures, competitions that the BITM conducts offer schools to participate in building a culture of science. Her own experience with the museum dates back to 1984 since when she has been active in bringing students to the museum. She also said that her school has been using the BITM as a laboratory, for its wide range of offerings directed to the students. Commenting especially on the Innovation Hub, she pointed out that the enthusiasm of students was very high as this was not a part of their curricular activities.

Image 3.5: Students at the Innovation Hub learning computer-aided design

From my visit and subsequent discussions with all the major stakeholders--the museum director, the curator, the technical officer in charge of explaining scientific principles to students, the school students and teachers—it was evident that innovation as a narrative for local and social development (and therefore the need for active participation) has been embraced by all those connected with the development and use of the space. The curator pointed out that the decision to harness local, grassroots innovators by the government was welcomed by the museum. The BITM, because of its proven expertise in the field of informal science communication, was chosen by the National Innovation Council as one of the institutions which would provide the space and the resource persons for the public to engage in scientific activities. The curator also mentioned that the facilities provided at the Hub would enthuse young students to learn more about the state of the art in science and technology and would support them to choose a career in sciences. These thoughts

were mirrored by the teachers who accompanied the students to the session. While they did not mention the phrase 'grassroots innovation', they were quick to point out that the museum has been used for many years by them as a laboratory for the practical component in the teaching syllabi, as a space for scientific debates on persisting social issues like health and pollution, and especially in the case of Innovation Hub, as a space to train students to participate in local, regional and national science fairs and competitions. As for the students, their enthusiasm was palpable as they maneuvered the robot engine and learnt computer-aided design, lessons which they would not encounter in a school classroom. They pointed out that in fact the hours spent in the Innovation Hub sessions would not be counted towards their final grade, and that it was something they had taken up voluntarily to supplement their classroom work, and to learn more about scientific applications.

The major drawback of the space is its exclusiveness. It is open only to members and the fee for membership (both institutional and individual) could be too high for many groups of students who would otherwise benefit from such a space. However, the museum is trying to address this issue by providing scholarships for students who show promise but otherwise cannot access the facility. The other problem lies in the different imaginaries of grassroots innovators. From the examples provided in the documents of the think-tanks, one will find instances of rural low-cost innovation such as a device to ease the process of climbing trees or a paddy thrasher. Would it be possible to communicate these inventions as grassroots innovation to a primarily city-dwelling group of students learning computer-aided design to program robots? These two groups should be able to learn from each other so that the vision of sustaining a young democracy of innovators starts to appear realistic.

However, as an example of how 'promotion of scientific temper' is interpreted by BITM, the interviews and participant observation carried out at the BITM proved to be particularly illustrative. The narrative of 'scientific temper' has surely broadened significantly from Jawaharlal Nehru's first use of the phrase in his monograph *The Discovery of India* (1946), where he pitted it against superstitions and irrational thinking to indicate what was holding the country behind. From its origin at a time when India was at the cusp of independence, the phrase today (as was discussed briefly in the Introduction and will be dealt with in detail in the subsequent chapter) has traversed a long road through multiple policy

documents, including its mention as one of the ten fundamental duties of every Indian citizen in the Constitution of India. The aim of the Innovation Hub, as it emerged from the discussion in the chapter, is to provide a platform to young students from schools and universities (undergraduates) where they will not only receive scientific training but also will be encouraged to come up with innovative solutions to various technical and social problems. Thus, 'scientific temper' today in India, as interpreted by the museum, not only indicates the rejection of extra-scientific methods but also active training of the young population in scientific methods so that they can be absorbed by the growing innovation networks. The promotion and inculcation of scientific temper is a constitutional duty of every citizen because of its perceived role in the nation-building process. It is evident that this is a narrative of optimism (as discussed in the first part of the previous chapter) because of the role that science and technology have been accorded in the national developmental process.

Chapter 4. Storytelling and science communication: some reflections on narratives from museums around the world

In the previous chapters, one of the issues that has emerged in multiple discussions is how the debate in science communication literature has moved from the deficit to the dialogue model, especially following the publication of the 'Science and Society' report of the House of Lords, UK in 2000. This has influenced communication policies and strategies of museums as well, with focus shifting from public understanding of science to public participation and engagement with science (at least what concerns the rhetoric of museums, including goals, objectives, mission and vision statements). From a survey of the museum literature, it is evident that the discussion on public participation has been brought to the forefront, especially thanks to the seminal work of Nina Simon (2010), *The Participatory Museum*. However, often the concept is discussed in connection with participatory exhibits and tools of participation (for example, enhanced use of ICT and virtual reality) or in terms of co-creation of exhibits and in some cases, public engagement in decision-making processes of the museum. In this chapter, I shall shift my focus to an issue which has not received much academic attention: the use of storytelling as a communication tool in science museums. The starting point, rather, the starting points to this discussion are two articles which deserve further reflection.

The first is a recent article written by British museologist Jane Nielsen (2017) on the importance of narratives and storytelling in museum practices. She posits the argument that while in the recent times, museums have been using terms like 'meaning making', 'interaction' and 'interpretation' in describing their functions and aims, these phrases have not yet been defined adequately for museological purposes, and that they retain their ambiguity. Thus, in the article Nielsen seeks to explain these terms better, especially in the context of communication in museums. She sees these concepts as a part of the creation of a narrative for better communication. A narrative, as argued by Nielsen, is a structure that 'can be based on emotional, learning, educational, interactive, individual or social, imaginative, fictive or non-fictive, digital or non-digital, subjective or objective

engagements.' (p. 6) An important aspect of creating an engaging narrative is storytelling, which as the author points out, supports meaning making and interpretation. Stories are useful for illustrating points, for engaging audiences and for recollection of memories. They provide methods to museums for 'emphasising meaning, understanding and feelings.' (p.7) Nielsen further notes that today storytelling in museums is not just restricted to narratives being communicated to visitors, but also to the creation of internal logic for realizing the organizational potential of an institution.

The second article, written by American science communication scholar Michael Dahlstrom (2014) discusses the role of narratives and stories in science communication to non-expert audiences. Dahlstrom begins his article by pointing out that stories often have a negative connotation in science as they are viewed as less rigorous. However, research has shown that narratives are much more engaging for non-expert audiences than, as the author calls it, logical-scientific communication. The other crucial issue that he highlights is that most non-expert audiences derive knowledge about sciences from mass media which rely on stories, anecdotes and other similar narrative formats. How does logical-scientific communication differ from narratives? The author explains that 'Logical-scientific communication is context-free in that it deals with the understanding of facts that retain their meaning independently from their surrounding units of information… In contrast, narrative communication is context-dependent because it derives its meaning from the ongoing cause-and-effects structure of the temporal events of which it is comprised.' (p.13614) These differences in turn give rise to two distinct styles of comprehension: the former, termed as paradigmatic pathway favours a scientific evidence based encoding of knowledge, while the narrative pathway focuses on situations and anecdotes. Empirical research has shown that the narrative pathway leads to better processing and retaining of information.

From the discussion of these articles, the following related issues emerge.

1. Several concepts associated with engagement in museums, like meaning making and interaction retain their ambiguity as the discussion on them is more theoretical, ie. not sufficiently grounded in museological practices

2. Museums have been using storytelling and narrative methods to interact better with their audiences.
3. Narratives can be presented in many formats and are optimal for enhancing understanding while eliciting emotional responses.
4. Narrative methods have been proven to be better suited to address a non-scientific audience on scientific issues.

Based on these assumptions, I will direct attention in this chapter to museological practices in science museums, with examples from around the world, which show how museum professionals have been increasingly embracing narrative storytelling approaches to engage the visitors better with the content they intend to communicate. Science museums are important spaces for informal science learning, and increasingly considered to be a platform where the public can engage with multiple debates about science and technology that directly affect their lives. Thus, it is an absolute necessity that the visitors not only have the tools to engage but also the understanding of the content. In fact, as it has become evident from several interviews I carried out with museum professionals from different sides of the world, also from NCSM, that science centres are also increasingly adopting a context-based storytelling style for better comprehension.

4.1. On communication and engagement in science museums

Based on a literature survey of various communication models of museums, Eilean Hooper-Greenhill (1999) mentions that scholars Knez and Wright (1970) discussed the difference between science museums vis-à-vis arts museums in terms of the medium of communication. According to Knez and Wright, in the case of art museums, objects constitute the medium, as opposed to science museums where verbal symbols, such as written or spoken words, are important as the medium in an exhibition. Even today, with multiple new methods (analogue, digital, web) of communication that the museum employs to communicate with the public, the importance of the spoken/written word cannot be overemphasized.

In Science Technology Society (STS) literature and in museum studies, there have been a growing number of articles which discuss how science museums have been focusing on better engagement strategies with audiences for various purposes. After a literature survey, the following themes emerge as the most prominent ones: improved use of technology in interactive exhibits as a strategy for enhancing visitors' experience (eg. Heath and vom Lehn, 2008); use of social media for public participation (eg. Kidd, 2011); the museum space itself as a site where science and society issues can be deliberated upon (eg. Cameron and Deslandes, 2011); or the need to include voices of the public in the governance of science museums and centres (eg. Bandelli et al, 2009). However, very few address the role of history (especially, historical narratives) of the scientific objects in augmenting communication and enhancing awareness of their importance in the society. Concomitantly, the connections between science and social histories, memories and heritage are left unexplored in the field of science communication, even though they have been given prominence in science education discursive practices (Matthews, 2015).

Museum studies literature shows us that the science museum experience should be described both in terms of the aesthetic and a cognitive dimension (Kirchberg and Troendle, 2012; Pekarik, Doering, and Karns, 1999). Kirchberg and Troendle note that 'The conventional expectations for appreciating objects (at art museums) and being triggered intellectually (at science museums) seem to prevail.' Scientific objects are twice removed from the visitor: firstly because of the technicality of their structure and functions; and secondly, for their intangible quality. An object of science can surely cause a sense of wonder in the minds of the visitors but the awe cannot be sustained unless it is accompanied by an exposition of the process which goes into the making of the object, and the way in which it functions or has functioned. Therefore, it is understandable that science museums and centres around the world, including, for example, Exploratorium[97] or the Science Museum Group, UK, continue to address the issue of better engagement techniques with

[97] See Exploratorium Annual Report of Philanthropy 2013, for example. The year is of particular importance as that was when Exploratorium relocated to its present venue. A fresh new location was complimented with a more inclusive perspective for global outreach. More can be found here: https://exploratorium.edu/sites/default/files/pdfs/annualreport.pdf (last accessed January 2017).

visitors and the need for state-of-the-art communication strategies to be more inclusive. (Macdonald, 2010). They also recognise the changing social demographics and new challenges to responsibly communicate science to a wide range of public which includes immigrants and a greater number of international visitors. In this scenario, under the rubric of science, we must consider not just scientific objects but also social processes which are at work in the creation of the object and dissemination of the knowledge of its uses as well as reception of that object by the public. Visitor studies carried out in Australia tell us that the public perceives the museum not just as a place for historical reflection, but also where the past is contextualised for the present, and the future (Cameron, 2005). The role of social histories of science must then be considered as crucial for allowing the visitors to better engage with the displays. This point of view was expressed clearly by former curator of the Museum of the History of Science at the University of Oxford, Jim Bennett (2003) in the following lines:

> We learn science in schools, colleges and universities and go to museums not just for reinforcement but commentary. Whatever critical perspectives they adopt, exhibitions must therefore take up the challenge of being meta-representations with respect to science. Our visitors deserve this facility, which they will not readily find elsewhere, and history of science provides one of the most interesting, appealing and profound resources for an enriched understanding… (pp.179-180)

The connection between history of science and public understanding of science is strongly underscored in this comment, as is the importance of incorporating historical and social contexts in museum exhibits, as museums provide a unique space to the public to engage with debates on science in society. Indian science communication scholars Raza, Singh and Dutt (2002), while surveying STS literature, noted further that science is a cultural activity, and that the generation of scientific knowledge is to be understood within the framework of culture.

> The criticisms of the two-culture and deficit models played a crucial role in the emergence of a more realistic perspective usually termed the "contextual approach" (Godin and Gingras 2000,45). The two-culture model placed science and culture in two distinctive spheres, often in opposition to each other, whereas the deficit model allowed diffusion of ideas and information from science to culture via mediators

> (like communicators of science). Godin and Gingras (2000), while analyzing the evolutionary trajectory of various approaches, proposed "a third model." They argued that the scientific knowledge generation and its appropriation is essentially a form of social organization of culture (Godin and Gingras 2000, 53). Their model defines the science-technology-society relationship in terms of two concentric circles. Science and technology come first and are placed in the center of a large circle designated as culture. (Raza et al, 2002, 295-296)

STS researcher Steve Miller also wrote about the "contextual approach" while discussing the increasing importance of the dialogue model of communication, and argued that the approach can be found embodied in the 2000 House of Lords Report on 'Science and Society'. (2001: 117). Tracing the works of HM Collins, Trevor Pinch and Bruno Latour, he wrote that scientific processes could not be discussed only in terms of hypothesis-experimentation-verification/falsification, because there are a lot of scientific debates, where social checks and balances come into play, especially for what concerns new areas of science and technology, especially the 'science-in-the-making' variety. These arguments paved the way for (at least the discussion on the need of) greater dialogue and rising importance of the layperson's knowledge (which was earlier not considered in the 'deficit model') in scientific decision-making and policy making efforts.

My endeavour will be to build upon these remarks by examining how histories, memories and culture form the context to understand the development of science and technology, and are therefore important for science communication, not only because they provide the narrative conduit to engage audiences but also as they are crucial to the science-technology-society dynamics. The study of narration of these connections in the museum space is relatively new in museum studies (Nielsen, 2017) as well as in public communication of science and technology (PCST) literature. I will be drawing upon my fieldwork in India (a country where, as I will argue later, science ought to be discussed as the key component in building the narrative of independent India), and personal interviews carried out with museum officials from Italy, Denmark and the United States to illustrate how museum practitioners are addressing this issue of storytelling in different parts of the world. The following sections of the chapter will discuss how history and cultural narratives can be

and are being used by museums to tell diverse stories to the public. Examples will include cases I encountered during my field visits to museums in these countries. Subsequently, the issue of contextualizing the narratives of galleries of NCSM will be discussed, regarding increasing contextual displays in science centres (and not only museums). As one of the officials of the Washington DC based Association of Science and Technology Centers (ASTC) observed[98], science centres, previously famous for their hands-on style of singular exhibits, are increasingly creating galleries which tell stories to the public. This was corroborated by an NCSM official as well. The chapter will conclude with the case of 'scientific temper', a crucial inheritance of independent India and its policies of becoming self-dependent, will be posited as independent India's legacy and a key to understanding the national focus on science and technology for social development. Here it is important also to reconsider a position taken in the second chapter, concurring with heritage scholar Tim Winter (2013) that young nations have a different predisposition and relationship with the past, and their outlook is geared towards a vision of the future[99]. I also argued in the same chapter that the clause of promotion of scientific temper which is present in multiple policy-level documents of the central government and the objectives of numerous public institutions (especially those engaged with science education and communication) in independent India, is closely connected to the rhetoric of reaping 'demographic dividends' that a young population with a high degree of scientific awareness and innovative capabilities can provide. Furthermore, while public institutions are supposed to promote scientific temper, the citizens are constitutionally bound to inculcate scientific temper. I will argue in this chapter, that the constant occurrence of this phrase and its persisting relevance in government documents, most significant of them being the Indian Constitution, reveals to us that the importance of the journey of the phrase 'scientific temper' is a story worth telling to the Indian public. While the clause of promotion of

[98] ASTC is an international organization which provides professional support to science centres and museums in the US primarily and around the world. They advocate the cause and interests of science centres in society and specifically to policy makers. The text of the interview with the ASTC professional can be found in the Appendix.

[99] The NCSM's focus on facilitating the creation of a society with scientific temper and its role in the nation-building process has already been discussed in the second part of the second chapter in the dissertation. In this chapter, the intention is to understand the clause of the promotion of scientific temper as a part of independent India's heritage.

scientific temper is an important element of the NCSM's *raison d'etre*, and prominently features in its own narrative of institutional objectives, the issue of how it is interpreted in the realm of science communication is a complicated debate and requires extensive research. We saw an example in the previous chapter with the activities at the Innovation Hub, where young students are encouraged to take up STEM disciplines as careers. This surely is one of the many interpretations of promotion of scientific temper; and to understand its nuanced meanings, it is important to trace the history of the phrase and what it stands for in contemporary India. As Indian science museums and centres move towards engaging their audiences with contextualized displays of science and technology, this would be an opportune moment to narrate the history of 'scientific temper'. However, before we move to NCSM and storytelling, it is important to look at examples from museum practices around the world and identify some of the storytelling techniques being adopted by science museums and centres globally. Based on my own trips during the PhD, I will present two brief case studies in the following section.

4.2 Narrating science and technology in museums: two examples from history of science and technology museums

Every object has at least one story to tell. This statement must be read alongside the fact that a story needs objects as fulcrum for the narration, especially in the case of museums (more so than centres). In diverse disciplines in social sciences today, the object is not inanimate anymore. In fact, it is an active agent which renders nuances to meanings as is evident in the approach of actor-network theory of Latour and Callon. Objects have a social life, in the sense that their meaning is 'inscribed in their forms, their uses, their trajectories' (Appadurai 1985, 5). Following this premise, scientific instruments and finished artifacts therefore are not just the perfect culmination of human intelligence and design. They have lived their own lives before entering the museums and the onus is on museum practitioners to narrate their stories to the audience and reveal the processes which went into their making, the people who created and used them, the society which they lived in and served, and their interactions. Their biographies are not solely a part of the history of science; they also reflect the heritage of the place where they were created and used, and often continue

to be a part of the living heritage of that same place. Museums today are aware of the importance of projecting these biographies for creating an emotional connection between objects and visitors. In the next section, one such example is discussed in detail.

4.2.1 Biography of a silk mill: narrating local history through objects of technology

The Museo del Patrimonio Industriale (Museum of Industrial Heritage) in Bologna is the first example used in this chapter of a local museum which presents the economic and social history of a city through its collection of objects signifying its long industrial heritage[100]. Among its galleries, which include an exposition on Bologna as a world-leading centre in the history of packaging[101] and another as the place of a rich culture of automation, one presents the history of silk production in the early modern period of this medieval city.

The centerpiece of the gallery 'Bologna dell'acqua e della seta' (roughly translated to 'Bologna: the city of water and silk') is a magnificent structure, the Bolognese silk mill, scaled at 1:2. The model itself is 3,4 meters tall and 2,3 meters in diameter. The technology is fascinating because the machine (called *valichi*) encompasses multiple stages of silk production: reeling (the process of taking filaments of silk thread from the cocoon), throwing (the process which involves twisting the thread) and winding the threads around bobbins.

[100] For further information on the museum, its website is a useful source. http://www.museibologna.it/patrimonioindustriale/introduzione/51896 (last accessed January 2017). This is the museum of the industrial heritage of Bologna which is managed by the *comune*, or the municipality of Bologna. It houses original objects and scaled replicas of technological artifacts associated with the history of the city. Galleries include the history of Bologna as a city of silk, automobiles and the packaging industry. It is also interesting to note that the website does not have an English version.

[101] An earlier PhD dissertation produced at the Department of Philosophy and Communication, University of Bologna, written by Matteo Serafini (2011), titled *Technological innovation in Emilia-Romagna: knowledge, practice, strategies*, provides detailed history of the packaging industry in the region of Emilia-Romagna in Italy.

Image 4.1: The bottom part of the model. Notice the reels, the spindles and the thread-woven bobbins. In Carlo Poni's words, 'The threads as they came off the bobbins were twisted by flyers, rotating on their own spindles, and were collected in the reels above them.' The description was that of the mechanism of an early model of this very same Bolognese machine.

Image 4.2: View from the top of the circular silk mill model

Apart from the obvious technical excellence that will grab the attention of technology aficionados, the circular silk mill has a very interesting story to tell. A derivation of the circular Florentine hand-throwing machine, the Bolognese silk mill was a technology that travelled from Lucca, in the hands of the technician Bolognino di Borghesano da Lucca, who substituted manpower with engine (Poni, 1999) in the year 1341. The engine in this case was a waterwheel, in other words the mill was driven by hydraulic power. The memory of the existence of these complex machines as the core of a thriving silk industry was lost because the industry declined and disappeared, for the reasons discussed by the historian Carlo Poni. No material traces remain of this, and reconstruction of the shape of the model was based on a reference drawing from various 'theatres of machines' among which was one done in Trento by German architect Heinrich Schickhardt in 1599. The drawings alone could not have achieved the reconstruction; there was also an extraordinary amount of experimental work done, to a large extent based on trial and error, in the attempt to "translate" those drawings into a working machinery. For example, a considerable amount of research had to be carried out on the specufic qualities and properties of the materials used in the construction of the machine.

The powerful centerpiece initiates multiple narratives in this case. Where was the hydraulic power being generated from? What was the source? Bologna of today, at a cursory glance does not seem to facilitate a structure like this, because it does not have a significant source of water power close by. However, the history of the city reveals something quite the contrary: that Bologna was a city of canals well into the nineteenth century, as is evident from the displays (photos, videos and texts) presented in the museum. Using the reconstructed mill as the entry point to the narration, the social life of workers organized around the mills from the medieval times, sketches of their habitation are presented in the story of silk production in Bologna.

Image 4.3: Sketch of the silk mill. Notice how the water flows in from the canals. This water then powers the engine which runs the machinery.

Apart from the centerpiece, the exhibit consists of small scale models of the houses of the mill workers, photographs of Bologna in the old days with the canals and even a simulation of how it must have been for the people carrying their silk goods from the city on their boats to the Adriatic Sea. The use of multimedia is done efficiently to give the visitor a well-rounded story of what it was like in the bygone era.

The key lessons learnt from the gallery of the Museo del Patrimonio Industriale can be summed up in the following points:

- **The narration of a story**: Every historical event, object, artifact has multiple stories to tell. Trying to tell all of them in an exhibit can make the narration fuzzy. In this case, it was a reconstruction of the social history of Bologna through the prism of production of silk and the growth of a technology which was unparalleled in its heydays. This gives us an insight into Bologna as a highly technologically advanced city in late medieval times. Here it is also important to recollect the fact that such a sophisticated narration of the history of silk production would not have

been possible without the efforts of historian Carlo Poni, whose research made it possible to reconstruct the centerpiece.

- **The effective use of a centerpiece**: In order to be effective, A story has to revolve around a leverage point which will trigger the curiosity of visitors. It can be an awe-inspiring piece of technology, painting, artifact, object which will draw the attention of the viewer. In this case, the centerpiece is the reconstructed scaled-down version of the circular silk mill. Interestingly, it appears almost at the end of the exhibit, by which time, the visitors have already learned a number of things about it, like the sketches of the mill, how the motor was run, how the workers' lives were organized.
- **Narrative focus**: While the centerpiece remains the most important part of the narrative puzzle, all other artifacts and multimedia devices should be focused in augmenting the understanding of the topic in question. In this case, it is the history of silk production in Bologna whose story is told through the technological heritage of the city. The narration weaves seamlessly the social life of the artisans and craftsmen who made use of the technology to produce silk goods and contributed to the economy of the city.

4.2.2 Narrative twists at the Viking Ship Museum, Roskilde, Denmark

These three qualities can also be observed in the narrative techniques adopted by the Viking Ship Museum in Roskilde, Denmark, whose primary collection include remains of five Viking-era boats (which were discovered in the sea thanks to the efforts of archaeologists). Its website states that 'The museum's exhibitions are modern historical narratives about the Vikings and their ships'[102] where the Scandinavian heritage of Vikings (not exactly a positive one as Vikings in popular imagination are known to have been seafaring

[102] See http://www.vikingeskibsmuseet.dk/en/visit-the-museum/exhibitions/ (last accessed March 2017). This is the English version of the website, clearly indicating their intended audience is greater than only the local patrons. Apart from the exhibitions and the activities at the museum, it also carries information on the research and educational support that they provide to teachers and researchers.

conquerors) is treated with a refreshing narrative turn. There is a strong narrative focus on the five original artifacts as all the other displays and participatory activities are designed to reconstruct the technology from the Viking age (between the 8th and 11th century in Europe). Visitors at the museum, especially foreigners, who are curious to find traces of the image of Vikings they are accustomed to, are instead confronted with a complex yet fascinating history of their boat building technology, through the restored Viking ships on display in the main hall and the various activities designed for diverse age groups that reinforce the narrative of a sophisticated group of brave seafarers from the medieval times[103]. In a personal interview carried out in 2013, then Head of Learning and Activities of the museum indicated that it was intentional on the museum management's part to juxtapose the two supposedly disparate lines of thoughts together: that the strong recall value of Vikings is generally one of a savage people (as per popular culture outside Denmark), and that of an older group of adventurers from the early medieval age who built sophisticated boats. This juxtaposition results in creating a new positive recall value about Vikings and demands of its visitors for a reassessment of their pre-conceived notions. The technology of how the boats were built to sail through rough waters is impressive indeed, and the museum employs multiple methods to reinforce the boat-building processes. The message of technological objects and processes is effectively communicated, and more specifically mediated, by calling into attention Viking history and heritage.

[103] See Focus A below for a detailed description of the Viking Ship Museum and its activities.

Image 4.4: Main exposition hall of Viking Ship Museum, Roskilde. See here are the remains of the Viking-era boats.

Image 4.5: A hands-on task at the museum which allows visitors to build a paper boat in the replica of the original Viking boats.

4.3 Telling stories with (a) few artifacts: storytelling in new contexts

> '… a 'heritage culture' has rapidly come to the fore in many countries around the world, one that is expected to fulfill a multitude of ends. Its ascendancy needs to be read, in part, as an expression of contemporary social and political life and shifting modes of governance, and, in part due to the formation of identities and economies tied to new modes of post-industrial, globalised capital production' (Winter and Daly, 2012).

> '…there are dramatic differences in the demographic makeup in countries residing in the so-called 'global north' and 'global south', with the latter possessing a much higher percentage of younger people. Youthful societies tend to be more forward looking and future oriented, and, not withstanding particular national situations, are more confident than ageing societies about what that future will bring. This means the past – its remnants and residues, both material and immaterial – is more explicitly seen through a prism of present futures. For those experiencing the vitality of youth, history rarely bears as heavy. With age comes a greater sense of that which has been learnt and inherited, as well as a more nuanced but fraught appreciation of what is to be cherished and protected, anguished over and discarded. Memory is illustrative of regional differences here, described by some as an industry or obsession in the West; it is a theme that rarely features as prominently in the collective identities of younger societies (Rosenfeld, 2009).

These two quotes from scholars of critical heritage studies talk about the lack of preoccupation with the past as observed in the identity-formation of relatively younger societies, typically post-colonial nations emerging from a complex relationship with history, heritage and memory. They are illustrative of the arguments I propose in the following parts of the chapter which speak of a different grammar of museums with little or no artifacts and the consequent differences in approaching the issue of history of science and technology. I already argued in the second chapter why the science museum movement

in India shifted swiftly from the traditional artifacts-based space to that of science centres and hands-on exhibits and in the meanwhile challenged and redefined the notion of scientific heritage. A young country, in search of building a stable economy, has more preoccupations with the present and the future. In case of postcolonial states, the past anyway becomes a contested space of which the current generation can claim very little knowledge. There are also multiple societal problems in the developing world; and to mitigate them, science, technology and innovation become a part of the larger social developmental narrative of the future. Emdadul Islam, Director of the BITM stated in our personal interview, that the focus and priority of Indian science museums and centres has been science education and the promotion of scientific temper among the public. This has resulted in a paucity of displays on Indian history and heritage of science and technology. He said:

> *With the focus on creating science centres and providing an avenue to students to learn how science is done, the heritage of Indian science and technology has taken a backseat. However, there are specific galleries devoted to this topic at the Delhi and Mumbai science centres and a new gallery is coming up in Science City in Kolkata. In some of our galleries we have woven in stories of Indian ingenuity like the Mathematics and the Transportation galleries. We must admit that the Indian heritage in science and technology has not been well documented. However, we have done a special travelling exhibition (not one of the Mobile Science Exhibitions) which toured in the USA and Trinidad. We also need to find ways of interpreting old religious texts as well because there are gems of astronomical observations and mathematics to be found in some of them.*

The issue of lack of documentation of Indian history of science and technology has been stressed not only by academics (Phalkey, 2013) but also by a number of interviewees. G Rautela, the previous Director General of NCSM, mentioned clearly when asked: "What do you perceive as the biggest limitation of science museums in India with respect to objects?" His answer was: "Collection management, storage and conservation. At times, it has also been seen that it is difficult to determine and establish the source of certain objects."

The paucity of historical artefacts did not deter the museum professionals in India from hiring artisans to create replicas of important objects. During the early days of BITM, officials from European museums like Science Museum, London and Deutsches Museum, Munich visited Kolkata to provide guidance during the setting up of the galleries. Today exhibit prototypes are built entirely at the Central Research and Training Laboratory (CRTL), located at the NCSM headquarters in Kolkata. And now, galleries, as mentioned by one of the senior officials of the CRTL, have been using replicas, dioramas and panoramas, interactive interfaces, videos—the entire gamut of objects to narrate contextual stories. One of the new galleries that has come up in a regional science centre in a North Indian town called Dehra Dun[104] is about the Himalayas (since Dehra Dun is in the foothills of the Himalayas). The Himalayan Gallery not only talks about geology and geography of the mountain range, but also gives a glimpse of people's lives in the mountains, traditional practices and knowledge systems. It even houses a replica of the Amarnath caves[105], one of the holiest shrines for followers of Hinduism located in the Himalayas, thereby creating an instant connection with many of its visitors, who belong to the faith and/or are aware of its cultural implications.

However, this trend of contextualizing narratives of science is recent as it is in the case of NCSM museums and centres and the ones they have built in the various regions and then handed over to the respective regional governments. One of the foreign officials who has collaborated with NCSM for a significant period of time mentioned that the newly developed regional and suburban centres have galleries and exhibitions with a stronger narrative of science and society and the presence of human agency in the relationship. It

[104] See the webpage of the science centre here: http://www.ucost.in/blog/rsc/ (last accessed January 2017). The webpage provides information on the aims and objectives of the centre. It is a part of the website of the State Council of Science and Technology of the Uttarakhand region in North India. As already mentioned in the chapters before, the new centres, especially post 2003 are being jointly created with resources of NCSM and individual regional state governments. This is one such example.

[105] It is important to note the juxtaposition of a religious narrative with one on science and society. The religious narrative certainly holds pride of place in the heritage of the nation and its people, but is it a suitable topic of exposition in a science museum/centre? In so far as the history of scientific culture, in the West as well as in other parts of the world, is intrinsically liked to the history of religions, the answer is yes. However, this complex discussion has also to brought into the Indian science communication fold.

must also be noted here that the need to tell stories, as opposed to just educating the public with scientific facts was felt for long by NCSM officials. From some of the interviews carried out during my period at the NCSM as a researcher, it became apparent that as far as integrating historical/cultural context in the presentation of certain topics was concerned, the NCSM sought help from the Smithsonian to train aspiring museum professionals in the Master of Science (now MTech) course on Science Communication that the NCSM coordinates with Birla Institute of Technology and Science, one of the important engineering universities in Pilani, India. This led to Smithsonian professionals visiting the students (and the centres) on multiple occasions and teaching courses on history of science and public engagement. A future project could be carried out to identify the linking nodes in the partnership between Smithsonian and NCSM, especially because many of the alumni of the Master's course (that the NCSM has designed and offers every year to train young science graduates in the museum profession) are now directors of the smaller district-level centers and are engaged with the promotion of scientific temper at the grassroots level.

It would be interesting to further explore new possibilities of collaboration between the two institutions, especially in defining and exhibiting 'innovation'. The NCSM and Smithsonian both have dedicated spaces in their museums to communicate the concept of innovation—with their Innovation Hubs and Lemelson Center (and Spark Lab) respectively. Bernard Finn pointed out in a personal correspondence that the Lemelson Center exhibition titled 'Places of Invention' explores the process of innovation as history-in-making, which can be an effective method of visualizing scientific processes and making them accessible to the people. In the NCSM's efforts to promote scientific temper, this approach could be considered as a perfect fit in placing science and technology in the context of a changing social ecosystem which values rational, innovative thinking, much like the aspirations of the largely young population that they are catering to.

The 'Places of Invention' exhibition at the Lemelson Centre at the National Museum of American History deserves a longer discussion than the one provided here. However, the most important issue that has been discussed in the chapter is the importance of socio-cultural contexts in which science, technology and innovation thrive and how those

narratives can help communicate stories of science better to the public. The Lemelson exhibition takes off from this premise and showcases case studies like the rise of personal computers in Silicon Valley, California or the birth of hip-hop in Bronx, New York, which indicate the importance of human beings gathering in a location at a specific time period, and their exchanges leading to innovation and invention[106]. The storytelling in this exhibition is simple[107]: there are panels with texts, images, excerpts of interviews with innovators, and comparatively fewer objects. It instigates the visitors to think and share similar stories from their own knowledge and experiences, both on spot and online. For Indian museum professionals, this exhibition could indeed be a benchmark when they start to focus on contemporary Indian contributions to fields like information-technology, biotech, or space research.

Image 4.6: The Hip-Hop exhibit (Courtesy: TechRepublic[108])

[106] See https://www.si.edu/Exhibitions/Details/Places-of-Invention-4626 (last accessed January 2017) for a description of the 6 case studies that are presented in this exhibition. The exhibition's motto is 'Journey through time and place to discover the stories of people who lived, worked, played, collaborated, adapted, took risks, solved problems, and sometimes failed—all in the pursuit of something new. The exhibition examines what can happen when the right mix of inventive people, untapped resources, and inspiring surroundings come together.'

[107] To understand how the exhibition came into life, its various stages of planning and execution, see http://invention.si.edu/inventing-exhibition-part-4-4 (last accessed January 2017).

[108] Photo courtesy: http://www.techrepublic.com/pictures/photos-the-smithsonians-places-of-invention-exhibit-a-look-inside/4/ (last accessed January 2017)

4.4 Scientific temper: a story worth being told?

Given the vastly differing demographic situation in India, with extremely varied levels of access to education, cultural goods, social benefits, it is not surprising that science communicators in India have an exceedingly difficult task in engaging with visitors from all sections and intersections of the society. This is further complicated by the fact that oft-rigid religious narratives, ancient mythologies and superstitions are strongly believed and appropriated by people when discussing a scientific issue. In a paper written by researchers from the National Institute of Science, Technology and Development Studies (NISTADS) on public understanding of science in India, the difficulty of employing western paradigms in strictly Indian contexts is acknowledged, especially because a number of people take recourse to what they term, 'extra scientific' explanations (based on religious doctrines) for occurrence of natural phenomena. Even more controversially, religious texts have been appropriated by governmental officials and even ministers to make tall claims about India's ancient scientific achievements.[109]

It is in this context that the idea of scientific temper deserves to be discussed as an integral part of India's scientific heritage, and not just because of the legacy of Jawaharlal Nehru, the first Prime Minister of independent India, who coined this term implying a spirit of inquiry and reason.

[109] It would be important to note here that heritage, history and memories of a place certainly includes mythologies, epics, parables and religious texts. Schouten defines heritage as `the past processed through mythology, ideology, nationalism, local pride, romantic ideas, or just plain marketing into a commodity' (1995). The semantic category of heritage has undergone expansion in the latter half of the 20th century (Vecco, 2010), and with the formulation of the concept of intangible heritage, a large set of living practices hitherto unacknowledged, have been included or are at least being recognized as part of a place's heritage. One can also argue that intangible heritage has thrown the concept wide open and enabled a very large set of values, beliefs and traditions around the world to be included in what used to be a rather exclusive category.

4.4.1 Understanding the history of 'scientific temper'

Jawaharlal Nehru perceived scientific and industrial innovation as the need of the hour for a young India on the verge of independence. To promote these as the pillars of the then to-be-independent nation, he spoke about the idea of scientific temper in his work *The Discovery of India* (1946). A student of science himself in UK, Nehru's works bear testimony to his astute interest in reasoning and inquiry in the pursuit of knowledge. In a letter to his young daughter Indira he encourages her to seek out stories of every object, even the little pebble lying by the riverside, explaining that the pebble would have originated millions of years back high up in the mountains when it might have been a giant rock, which would have been transported by the sheer velocity of the mountainous river and getting eroded in the process to be transformed into its present state[110]. It is in such narratives that we can also locate the aforementioned scientific temper, a term so important at the dawn of independence that it was a few decades later included, as a fundamental duty of every Indian citizen, in the Indian Constitution, in Article 51(A) which mentions one of the fundamental duties of every Indian citizen is 'to develop the scientific temper, humanism and spirit of inquiry and reform'.

In the previous chapters, the phrase scientific temper has occurred several times in connection with the rhetoric of NCSM and its constituent museums, more specifically, its aims and goals. Here we shall take a closer look at the concept, starting with the context in which it was coined. 'Scientific temper' was first mentioned in Jawaharlal Nehru's *The Discovery of India* (1946), a monograph he wrote while imprisoned with other leaders agitating against Britain's rule over the country. Presented as a part-autobiography, part civilizational history of India, the patriotic overtones would be evident to any reader. While recounting India's many social problems, Nehru (1889-1964), who received an undergraduate science degree in Cambridge and was trained in Western traditions of

[110] The letter was the first of a series of 30, that Nehru wrote to his then young daughter Indira in the year 1928 when she was away in the hill station of Mussoorie, India in summer. These letters focused on natural history and stories of civilisations with special focus on India. They were published as the collection Letters from a father to his daughter (first published in 1929). They now form a part of multiple school curricula in India.

Enlightenment, emphasized the need to cultivate scientific thinking in order to approach life and its challenges. He explained that

> The applications of science are inevitable and unavoidable for all countries and peoples to-day. But something more than its application is necessary. It is the scientific approach, the adventurous and yet critical temper of science, the search for truth and new knowledge, the refusal to accept anything without testing and trial, the capacity to change previous conclusions in the face of new evidence, the reliance on observed fact and not on pre-conceived theory, the hard discipline of the mind—all this is necessary, not merely for the application of science but for life itself and the solution of its many problems. (Nehru 1946, 512)

It is important to pause here and reconsider the phrases 'scientific approach' and 'critical temper of science'. Not only did Nehru recognize the material benefits of foregrounding science and technology for the development of a nation, he strongly argued for science (scientific method and approach) as a 'philosophical approach'. (Arnold, 2013) This, I argue, following the work of historian David Arnold, is the enduring legacy of Nehru and his contribution to postcolonial scientific debates, what Arnold calls Nehruvian Science: the shift of understanding from science and technology as an imposition of Western authority to science and technology as answerable to the state and the public for its capability of delivering a better, inclusive, humane society, as well as the point of time in which this idea emerged, ie.in 1946, just before India's independence.

In 1947, the year of India's independence, when Nehru assumed power as the leader of the new state and formed his first cabinet, he kept the ministry dedicated to science and technology under his control. The decision bore testament to his understanding of the role of science in the building of the new nation. Historians Harrison and Johnson (2009) traced Nehru's narrative with regard to science and the building of a national identity, highlighting the fact that he claimed that a man could not be changed by law but an atmosphere could be created where people's actions would be governed by a scientific approach. The scholars further stressed that by doing so, he 'laid claim to an Indian share of the universal value of

science'. (Harrison and Johnson 2009, 1). On the issue of Nehru's preoccupations with science, David Arnold's work on Nehruvian science is particularly illuminating. He wrote:

> First, since for Nehru science was also a philosophical and literary pursuit, NS [Nehruvian Science] created a space for postcolonial ownership and subjectivity, establishing the centrality of science in the autobiography of the Indian nation. Second, since science stood for authority and a higher form of knowledge, NS sought to contest Western presumptions of a monopoly over science and to ground modern science in India's cultural traditions and contribution to world civilization. Third, while extolling the transnational foundations of modern science, Nehru understood science, intellectually and functionally, primarily in relation to India's national needs and Cold War ambitions. Fourth, NS presented science as a program of delivery, committed to redressing such basic social problems as ill health and poverty, an endeavor answerable to the state and the public it aspired to represent. (Arnold, 2013)

Based on this discussion, I posit the argument that Nehruvian science demands and deserves an engaging story that needs to be told in our museums as it is necessary to turn this philosophical concept and a moral duty into a convincing narrative for the public. However, one issue then would still remain: how to separate the political career of Nehru as one of the stalwarts of the Congress Party and focus only on the scientific-postcolonial legacy.

4.4.2 Post-Nehruvian period and the journey of 'scientific temper'

The Post-Nehruvian period in Indian politics saw growing governmental commitment in the spread of scientific temper through its science and technology policy statements. The inculcation of scientific temperament was added as a fundamental duty under Article 51 (A) (H) by the 42nd constitutional amendment, 'to develop the scientific temper, humanism and spirit of inquiry and reform'". In 2011, a 1981 scientific temper statement issued by intellectuals and academics (that placed scientific temper as an antidote to superstitious beliefs) was revisited and the outcome was a revised statement, what is now termed as the

"Palampur Declaration". This was followed by two international conferences and workshops, which built upon the conceptualisation of scientific temper as well as a plan of action to promote it. The latest Science, Technology and Innovation Policy 2013 also stresses on "promoting the spread of scientific temper amongst all sections of society" as the first objective, thereby cementing the importance of the phrase in successive government documents on the role of science and technology in society.[111]

The term continues to hold its importance in India's education policies and research institutes. The National Institute of Science Communication and Information Resources (NISCAIR), one of the publicly-funded institutions in India dedicated to communicating science to the masses, publishes children's journals in three of the major national languages, English, Hindi and Urdu, which are specifically targeted to inculcate a spirit of scientific reasoning. They also are responsible for the publication and circulation of the *Journal of Scientific Temper*, among others. More importantly for the purposes of this paper, the National Council of Science Museums, mentions the promotion of scientific temper as one of its primary goals, explaining it as 'To portray the growth of science and technology and their applications in industry and human welfare, with a view to develop scientific attitude and temper and to create, inculcate and sustain a general awareness amongst the people'[112]

The promotion of scientific temper in the building of the idea that is present-day India has been taken up as an objective by multiple national-level public institutions apart from those like NCSM which are created for the purpose of science communication. The National Council of Educational Research and Training (NCERT), an autonomous organization of the Government of India which advices central and regional state governments on matters of school education, lays emphasis on greater number of activities and exhibitions in schools to encourage scientific attitudes. In one of their official documents it is stated that

[111] Tyagi, BK. (2014). Fostering scientific temper. In *Vipnet News* 12(2), 1-3. Retrieved from http://www.vigyanprasar.gov.in/vipnet/february-2014/Vipnet-february-2014.pdf (last accessed January 2017)

[112] See http://ncsm.gov.in/?page_id=660 (last accessed January 2017). This is a page from the official website of NCSM and it outlines the objectives of the institution.

science communication practices in schools should acknowledge 'the development of science and mathematics as a major instrument for achieving goals of self-reliance, socio-economic and socio-ecological development of the nation and the world'[113]. Further to this, the importance of appreciating science and its role in 'meeting the challenges of life such as climate change, opening new avenues in the areas of agriculture, fertiliser, food processing, biotechnology, green energy, disaster management, information and communication technology, astronomy, transport, games and sports etc'[114] is highlighted. What is evident from all these documents is the creation of an agenda for the future, taking into consideration India's place in the world and the aspirations of its extremely young population, a large number of whom aspire to choose scientific and technical disciplines for higher studies and eventual careers. In a 2013 article in *The Hindu*, one of India's leading English newspapers, it was argued that the median age in India by 2020 is set to be 29, making it the youngest country in the world, and the population with the highest number of people in the working age thereby considerably improving the GDP[115]. (Shivakumar, 2013)

So what is the history of science and technology according to a country whose median age was 28 in 2014 while at the same time can claim multiple continuously living traditions for over 5000 years? These traditions also include ancient scientific practices, related to healthcare and good living through eating healthy food and practicing *Yoga*, for example[116]. And yet as with colonization around the world, these practices were relegated to the background and often deemed unfit by Western knowledge and even uprooted from the colonial education systems. Freedom from colonial rule did not reinstate the age-old practices, even though they are still allowed to be practiced by interested parties, and has

[113] See National Council of Educational Research and Training, Guidelines for the Preparation of Exhibits and Models (2014/15), http://www.ncert.nic.in/departments/nie/desm/publication/pdf/SLSMEE-2014-15%E2%80%93GuidelinesEnglish.pdf (last accessed January 2017).

[114] ibidem

[115] Shivakumar, G. (2013, April 17). India is set to become the youngest country by 2020. *The Hindu*.

[116] In fact, with the centre-right party in the government since 2014, public efforts are being made to promote ancient Indian knowledge and traditions, with *yoga* taking centre stage in multiple political and social discourses of developing India.

even found patronage under the present government. This brings us to the crucial question[117]: what is India's scientific and technological heritage? Is it the narrative of the golden age of ancient India with much advancement in mathematics, astronomy and medicine, or the present one of a *bonafide* technological power, showing efficiency and effectiveness in developing technologies imported from the west with limited resources and thereby showing the Indian ingenuity? Scholars in heritage studies (Winter, 2013; Rosenfeld, 2009) have noted the difference between western societies and their preoccupation with the past as opposed to the so-called global south with a more future-oriented outlook because of their youthful populations. Objectives of public institutions like NCSM certainly favour this forward-looking narrative of science and technology. If India's growing stature as a scientific and technological power is to be understood, it is going to be mandatory to look back at scientific temper as a crucial concept which the public institutions have been trying to promote since the birth of the post-colonial independent nation. The identification and recognition of the concept as the intangible heritage of independent India is necessary because while it is a living tradition, its preservation and acknowledgement and communication can lend scholars from around the world much-needed insights into how the country has shaped itself up as a science and technology innovator in a matter of about 68 years.

As Saroj Ghose summed up in a personal interview, the purpose of museums under NCSM was didactic, which led to the fabrication of educational exhibits rather than preservation of historical collections (there was also a paucity of artifacts). After setting up the first two museums of science and technology, the Birla Industrial and Technological Museum of Kolkata (1959) and the Visveswaraya Industrial and Technological Museum of Bangalore (1965), which were modeled upon the Deutsches Museum, there was a definitive change in the central government's approach to science popularization and communication. The NCSM as a premiere body for bringing science to the public was set up in 1978 and it found patronage from the Ministry of Culture as it was perceived to cater to the needs of a young nation at the cusp of technological breakthroughs. As Ghose explained in our

[117] Some of these topics have been dealt with in Chapter 2 Section 2 which discussed the role of NCSM in promoting scientific temper with less focus on the history and heritage of Indian science.

personal interview, scientific heritage and scientific temper are two opposing ends of an ideological spectrum—one looking towards the past and the other addressing the present and future. He agreed however that given the broadening of the category of heritage and what constitutes heritage, it would not be wrong to imply that scientific temper is a part of our living heritage, or at least as the legacy of independent India, particularly true in the context of India where its promotion is considered a fundamental duty of every citizen. As Emdadul Islam, Director of BITM further adds:

> *What we are definitely interested in promoting is science as culture through the concept of scientific temper. We want to communicate the idea that science is not just a set of rules and knowledge, but it is a way of thinking, of doing things. A person with scientific temper would be willing to receive inputs from everywhere without perception bias. It is of course difficult to cultivate it, nevertheless we have to try to inculcate the values of scientific and rational thinking among our youth and the rural population.*

4.4.3, Scientific temper, or the crystallisation of a scientific culture in independent India

Indian science communicators believe the discussion on scientific temper is a mainstay in Indian political discourse, transcending far beyond what constitutes science. A joint paper co-authored by heads of some of the most prominent science communication institutions of India (one of the authors was Ganga Rautela, now ex-Director of NCSM), and presented at one of the annual conferences of Public Communication of Science and Technology, traces the history of scientific temper to early 19th century, when European Enlightenment values had steadily started making inroads in Indian educational policies.

> The debate on the importance of modern science, science education, science popularisation and science-society relationships had started in India during the early 19th century, gained momentum during its second half. Phrases like ‘Modern Knowledge’, ‘Scientific Method’, ‘Western Models of investigation’, ‘Liberal and Enlightened System’ and ‘Scientific Spirit’ became part of the intellectual

> discourse. Though, initially, this debate was limited in its reach, by the turn of the century the emerging scientific community, social reformers, media, educationists and the leaders of resistance movement had started using these terms frequently. (Raza et al, 2014)

We may or may not argue about the origin of the phrase as a part of the colonial legacy, but the exact phrase has been traced back time and again to Nehru's work, and he has been accorded credit for the same by scientists and museum professionals alike. The term has especially found frequent mention in the media in the recent past after the ascension of a right-wing nationalistic government into power. Scientists and politicians (from multiple sides of the spectrum) have on several occasions discussed the need to promote scientific temper as a constitutional and moral duty reminding people that such a provision was made in Article 51(A) of the Indian Constitution[118]. (Bhargava, 2015). Thus, it can be argued that even if the origin of the phrase can be attributed to India's colonial past, the meaning of the phrase has been deliberated upon and expanded post-independence, thereby cementing its role in independent India's scientific heritage. Raza et al.'s (2014) article throws up yet another valid argument regarding the complexity of the phrase: "The project of 'spreading scientific temper', which is a constitutional duty of the citizens in India, is quite a complex one. Spreading scientific awareness is only a precondition for the creation of scientific temper. It follows that science popularisation cannot be an end in itself. The multi-dimensionality and non-linearity of processes involved in science communication forbid a direct causal linkage." (Raza et al, 2014). This is precisely why it is important for social scientists to study the proliferation of 'scientific temper' among Indian public not only through the many arms of the central and state governments but also schools, universities, traditional, digital and social media (both online and offline). In this dissertation, my attempt has been to look at the importance of the concept in the rhetoric and activities of

[118] Two relatively recent articles (both from 2015) in the national English daily, *The Hindu* talks about this issue of scientific temper. The phrase has been in the news often in the last years especially with a nationalist government with a strong religious identity in power (since 2014). See http://www.thehindu.com/news/cities/bangalore/promoting-scientific-temper-is-a-constitutional-duty/article7237328.ece and http://www.thehindu.com/opinion/op-ed/scientists-without-a-scientific-temper/article6794464.ece (last accessed February 2017)

the NCSM and its constituent units. I have also introduced the cognate concept of 'grassroots innovation' (in detail in the third chapter with reference to BITM's facility 'Innovation Hub), which provides a powerful social imaginary of the public as scientists and innovators. This is an interesting way to render a more tangible meaning to 'scientific temper'—the subject/citizen/innovator becomes the embodiment of the temper. British social anthropologist Connerton wrote in 1989 that the collective memory of a society about its past rests in performative activities. Indian histories and stories of science (and especially colonial science) have ignored the potential of the people. Scientific temper and grassroots innovation could be the answers to the heritage or better still, the culture of science that independent India seeks to define as its own contribution to the world.

One of the narratives that is largely missing from the museums of NCSM is the representation of science and technology contradictory to the societal developmental narrative, especially scientific controversies and instances of industrial disasters. From the available museum literature on India, one powerful case study emerged, regarding a museum commemorating the Bhopal Gas Tragedy of 1984. In her article, 'The Morality of Memory' (2011), Rama Lakshmi, who was also one of the curators of the memorial museum, commented upon Indian museums as the celebratory spaces of national pride, and the need to go beyond such narratives so that the voices of India's silent majority could also be heard. As she noted: The Bhopal story presents a unique, first ever opportunity to recast the Indian museum universe, which is dominated by celebratory, nationalist stories… A memorial and a museum at the Union Carbide site must speak to the ongoing arguments that contemporary India is having with itself—around frenetic industrial growth, displacement of communities and traditional livelihoods, and environmental protection.' (p. 69). In fact, the Remember Bhopal Museum is one of the first instances of a museum in India which has been built and curated by the survivors, and is not the governmental narrative of an industrial disaster. The webpage[119] of the museum states that 'The Remember Bhopal Museum is a survivor-led effort at collecting, archiving and exhibiting memories, artifacts and oral histories of the experience of the communities

[119] The link to the website of the museum can be found here: http://rememberbhopal.net/ (last accessed January 2017). It provides information not only on the museum but also the trustees and details of the tragedy. It is evident even with a quick glance at the pages that the focus is on the survivors.

affected by the aftermath of what has come to be known as the world's worst industrial disaster. The museum was inaugurated on the 30th anniversary of the disaster.' (in December 2014). In her essay, Lakshmi wrote about the delicate ideological battle that ensued once the state government decided to build a memorial. Multiple survivor groups felt that government appropriation of their narrative would only end up harming their cause to get justice. The weight of memory in a project that deals with a social justice movement is always heavy; and so was the case with the memorial in Bhopal. The industrial disaster at the pesticide factory of Union Carbide which led to leakage of poisonous gases not only killed over 4,000 people in the initial few days; even today residents suffer from chronic life-threatening illnesses. The factory and its present owners Dow Chemicals, have not been brought to book for the vast damages to the people, according to many survivor groups actively involved in the social movement. Thus, when the Madhya Pradesh State Government (which is the state of which Bhopal is the capital) decided to establish a memorial, survivors were skeptical of the conciliatory tone that the government was most likely to take. The present museum calls itself a 'survivor's museum' as it displays artefacts of personal use of survivors, oral histories, photographs, songs of protest and campaign posters, all of which recall the horrors of the disaster as well as the resilience and responses of the people in the face of it.

Here it must also be mentioned, that the science-centre model for science communication and informal learning has, from its early days (of Exploratorium exhibits), ignored narratives that paint science and technology in less than laudatory ways (Macdonald, 2002). In fact, Sharon Macdonald, a prolific academic in critical heritage and museum studies writes:

> As Jim Bennett has observed, objects have tended to be viewed with some suspicion by those concerned with promoting public understanding of science: `For a single--minded mission to explain ``the science'', objects are problematic because of their ambiguity and the richness of their associations for the viewer: their meaning and significance are not fixed, and visitors' reactions to them are difficult to control' (2000: 56). What has been especially characteristic of the public understanding of science approach in museums, he argues, has been an attempt to `carefully control' visitors' understandings. (Macdonald, 2002)

The unease with objects in case of NCSM and its constituent museums and centres can be interpreted in connection with the paucity of artefacts and lack of rigorous historical understanding due to very little research available on scientific objects and instruments in India. The above-mentioned argument however brings in a fresh point of view regarding why objects may not fulfil the desired story that the NCSM seeks to tell. However, if the NCSM is to promote scientific temper which involves supporting the critical faculties of the public, it is important for the management to consider bringing in people's voices on science and technology, from time to time, which showcase also the problematic entanglements of science, technology, industry and society.

Focus A: Meaning-making at the Viking Ship Museum, Roskilde, Denmark

One of the most significant voices in STS, Latour, in his actor-network theory talks about the 'actor' as someone who does not act on his/her own accord but is made to act by 'a vast array of entities swarming toward it' (Latour 2005, 46). This definition holds very true in case of the visitor in a museum, especially a well-designed one like the Vikingseskibsmuseet. From the point of entrance till the termination of the tour, the space is laid out in a way which requires the visitor to follow the leads inside the main hall of the museum. The ships are placed at the centre of the hall, with enough space to go around them and observe the pieces of technology. The fact that they are unique is reiterated by the guide (speaking in two languages in different slots) whose role is also to emphasise that The Vikings were not a 'savage' race that popular culture makes it out to be, but people in possession of sound skills in maritime technology.

The first room the main hall leads to has three activities planned for the visitors. They are encouraged try out clothes in the replica of attire from the Viking era; to learn to write letters of the Runic alphabet; and to watch a video about trips that the museum organizes for adventure lovers to sail the seas with a reconstructed Viking ship (which could then induce some visitors to try the experience out themselves). There is constant use of technology to show the various activities that the museum has carried out, starting with the actual archaeological excavation, instead of having passive plaques carrying information about them. One of the most impressive hands-on tasks I have witnessed in any museum, is present here, which allows children and young adults to try to build a paper version of the boat themselves, following instructions provided on a piece of paper with cutouts of the different parts of the boat. The place to exit from the various displays in the main hall sells souvenirs which also include printed books in various languages about the museum's curatorial activities, thereby completing the chain of repetitive events which are designed to convince the visitor about the primary narrative that the museum is trying to tell us, that of their interest in unearthing histories of technology and to show how technology not only involved heavy machinery in the early centuries but also smart thinking to brave extreme conditions in the seas.

The nexus of space—story—activity, that is how the museum professional who I interviewed during the visit described the viewer experience in the museum. The space helps create the story around which activities are woven. These activities, in return, influence the story that is narrated and given the scope of the story, the space is then negotiated accordingly. The activities that are built around this narrative are thus all related to the tasks that these seafaring people would have undertaken almost a thousand years back, like boat building, ropemaking, black smithy. The visitor gets to meet sections of the museum staff performing these activities, and they are encouraged to try some of them out. In the boatyard where similar boats are reconstructed, there is a smell of tar wafting in the air, which is supposed to induce an emotional response on the part of the visitors. This is in keeping with trends in heritage studies which seek to supplement textual narratives with experience, the senses and affective materialities (Tolia-Kelly, Waterton and Watson, 2017).

Conclusion

This dissertation has been an exploratory work on independent India's science museums: the reasons for their continued relevance in the society, their deep associations with governmental rhetoric on science and technology; and the narrative of science and technology they seek to communicate to the public with a growing repertoire of engagement and outreach activities. I focused on the activities of the National Council of Science Museums, Kolkata, the apex body of science museums and centres in India, which manages 25 institutions and is in charge of creating more centres across the country partnering with regional governments. Now it is opportune to revisit some of the questions highlighted in the 'Introduction'. As we have seen, in the recent years, especially in the case of museums in Western countries, according to museum management literature, public funding has been reducing drastically. Museums are now required to prove that they are worthy of public support. (Scott, 2011). Is this the case with the NCSM as well? Or does the Ministry of Culture, Government of India, which is the main funding body of the NCSM consider its role in science popularization, communication and education to be that of a public service provider? The answers to these are intrinsically tied to the question: What is the role of post-independent science museums in contemporary Indian society? The follow-up queries would then be: How is the role influenced by national science policies, given that the museums are publicly funded? Is there a certain public culture (narrative) of science that is promoted in the Indian science museum(s)?

The narrative path: reviewing the chapters

The four chapters that followed the introduction have tried deliberating on some of these questions, in turn formulating a new set of queries. The first chapter provided the backdrop to the institution of science museums in India, by situating it in a different temporal frame vis-a-vis the (history of the) institution of museums in the country. It was noted that the first museum came up in Kolkata (then Calcutta) in the early 19th century (in 1814), and was one of the first such institution in the entire Asia-Pacific region. The museum, aptly named Indian Museum, was created under the patronage of the Asiatic Society, an institution formed by British scholars interested in study and research of the East, or

Orientalists as they were called. The museum today showcases objects of archaeology, natural history and the arts. The history of the early establishment of the institution in a non-European setting deserves further critical thinking than what the dissertation has offered, as the focus here has been on contemporary (read post-independent) museums and centres of science in India. Suffice to say that the importance of the Asiatic Society in the history of British India merits attention on its own accord[120].

The first public museum specifically dedicated to the display of the history of science, technology and industry, Birla Industrial and Technological Museum (BITM, also in Kolkata) was opened after the independence and formation of the Indian union, in 1959. The goal of this new institution was the communication of the history of science and industry and their role in social transformation, albeit with a positivist narrative, as it was also initially inspired by the European science and technology museums established in the earlier part of the 20th century, which communicated the national histories of science and technology through their collections. Soon however, the opening of the Exploratorium in 1969 in San Francisco challenged the existing science museum space. The Exploratorium model of hands-on approach to science communication strongly favored science education and active participation in understanding of science. The success of Exploratorium and the growing interest in activity-based science training also to cater to the needs of the rural population combined to create a major motivation for science museum professionals in India to propose this new institution as the preferred model of science communication, which resulted in the formation of the National Council of Science Museums (NCSM) in 1978. The second chapter traced the history of the NCSM and commented on the goals,

[120] Indian historian of science, Sarkar wrote that "The nineteenth century was a very significant period in the history of modern India. It was during this period that the country witnessed the emergence of many intellectual currents in all aspects: religious, social, political, economic and cultural. For the colonial power, by the beginning of the nineteenth century, the empire had more or less been won. The job was to keep it, and to use it for profit." (2010: 90) This account of colonialism certainly provides an interesting counterpoint to the history of the museum provided on the official website, which to a great extent, glorifies the contributions of a specific member of the Asiatic Society, "To appreciate the history of the origin and growth of the Indian Museum we are to travel back to the last quarter of the 18th century when Sir William Jones a profound scholar devoted his life to the service of India, founded the Asiatic Society in 1784 in Kolkata." In yet another historical account of the birth of the Asiatic Society, Srabani Sen (2011) quoted primary sources that discussed the passion of William Jones about the East and its repertoires of knowledge.

objectives and activities of the organisation, and explained the multiple-tiered structure of decision-making.

It was noted that since its inception, the NCSM has grown greatly around the country, with the Council developing a nationwide infrastructure for science communication and informal science learning. The number of visitors to the twenty-seven museums and centres of NCSM has grown progressively over the years as well. In the 2013/14 Activity Report of NCSM, the number was recorded at over 9,1 million visitors to the various centres. In 2016, the Director of NCSM Headquarters revealed in a personal interview that another 15 million people participate in the various engagement and outreach programmes of the NCSM annually. While these numbers may seem small when compared to India's vast population as of now, it is clear that they are already significant for initiating discussions on the institution and its efficacy. Furthermore, with continued activity of building new centres and creating new engagement and outreach programmes, it can be speculated with little doubt that these numbers will grow in the coming years.

A close reading of recent documents like Ministry of Culture's Outcome Budget of 2016/17 as well as in-house publications like Annual Activity Reports of NCSM and its constituent museums, that was carried out in the second chapter, revealed that the budgetary allocation for NCSM has slowly yet steadily increased over the last few years (or at times stayed stable, but has not reduced). This was corroborated by employees of the top management of the institution who claimed that paucity of funds was not an issue for them. This is in fact an interesting finding for what concerns studies in museum management where multiple scholars have pointed out the drying up of public funding for museums and similar institutions. While present literature in science centre/museum management assess the managerial boards of centres as (at times) resembling those of Wall Street (Bandelli et al, 2009) or that the directorial jobs revolve mainly around fund-raising and ensuring efficiency (Griffin, 2008), we find a distinctly different model of governance in the Indian context. Without the worries of lack of funding, the NCSM's management is able to propose multiple new projects each year. While the allocation of money is decided by the Ministry of Culture, the decision to create new galleries, upgrade facilities or to carry out specific activities happen at the level of each individual institution of the NCSM. So even if in terms of financial allocation, the Council is clearly dependent solely on the Ministry,

the decision-making process for new projects and everyday management follows a bottom up approach. The second chapter also discussed the concept of scientific temper in some detail, connecting it to the future-oriented narrative that the NCSM espouses for the developmental goals of India. This was taken up further in the fourth chapter which argued that the history of the phrase 'scientific temper' (and its continuous presence in the official documents of many public institutions dedicated to science education and communication) was a worthy story to be narrated to the public. It concluded with the discussion on how science and technology are important components in the creation of a nation's own narrative, and how 'scientific temper', a term coined by India's first Prime Minister, Jawaharlal Nehru, and a crucial inheritance of independent India, is key to understanding the Indian national narrative of science for social development.

The second chapter also initiated the discussion on the role of BITM as a national-level unit of the NCSM. The following chapter then probed further into the large number of activities that an important constituent unit of NCSM would undertake—including, but not limited to, creation and maintenance of galleries, engagement and outreach activities for various socio-economic groups. To address the history of the BITM in detail, the third chapter made use of the museum's special publications, archives of both BITM and NCSM and interviews with those who have been in charge of helming these institutions. After acquainting the reader with the historical narrative, that narrative of the chapter moved inside the BITM's physical space to review some of the galleries, and analysed the feedback of about 93 visitors to the museum (responses were collected by NCSM officials) on their experience of the museum. These responses revealed a great degree of satisfaction on the part of the visitors with the content of the galleries and special shows, in addition to the overall services of the staff. In the final section of the chapter, two extension activities of the BITM, the Innovation Hub (a space to engage young students with hands-on science learning) and Mobile Science Exhibition (an outreach programme targeted towards the rural population) were discussed in the light of the NCSM objective of 'promotion of scientific temper' among masses. A detailed example of participation and informal science-learning at the BITM Innovation Hub proved to be particularly revealing in terms of how the museum has interpreted the objective. From my visit to the Hub and discussions with all the major stakeholders of the BITM--the museum director, the curator, the technical

officer in charge of explaining scientific principles to students, the school students and teachers—it was evident that innovation as a narrative for local and social development (and therefore the need for active participation) has been embraced by all those connected with the development and use of the space. The curator pointed out that the decision to harness local, grassroots innovators by the central government was welcomed by the museum. The BITM, because of its proven expertise in the field of informal science communication and education, was chosen by government agencies as one of the institutions which would provide the space and the resource persons for the public to engage with the topic of innovation. The curator of the Hub also mentioned that the space would enthuse young students to learn more about the state of the art in science and technology and would support them to choose a career in sciences. The aim of the Innovation Hub, as it emerged from the discussion in the chapter, is to provide a platform to young students from schools and universities (undergraduates) where they will not only receive scientific training but also will be encouraged to come up with innovative solutions to various technical and social problems. It is an illustrative example of how the BITM (and indeed the NCSM) interpret the clause of 'promotion of scientific temper'.

Limitations and further directions

This dissertation has paid significant attention to science and technology policies of the Indian government, and has established the strong relationship between public policies and science communication (and informal science education) activities of the NCSM. It has also discussed at length the issue of scientific temper, especially its promotion (that is the duty of all science communication and education institutions). From its beginning in the pages of Nehru's *The Discovery of India* (1946), the phrase has traversed a long distance in various policy documents of post-independent India, most notably, making a place for itself in the Indian Constitution. Today, not only are institutions like NCSM supposed to promote scientific temper; but, in fact, every Indian citizen has the constitutional obligation to inculcate the spirit of scientific temper, inquiry and humanism, as it is one of the ten fundamental duties of Indian citizens. In the chapters (especially the second and third), I have presented two sites of engagement and participation, the Innovation Hub and the Mobile Science Exhibitions, as diverse examples of NCSM's promotion of scientific

temper. However, a significant limitation of the dissertation is the lack of representation of public voice[121], and their interpretation of a clause like scientific temper, or in fact, their detailed feedback on the various engagement and outreach activities of NCSM. In fact, as the rural population is the primary audience for the Mobile Science Exhibitions, it would be worthwhile to pursue this direction of research, which would allow me to travel to the rural areas and interview people there, so that I would have a rich data set to analyse how scientific temper is interpreted by the rural population and to comment on the efficacy of NCSM's modes of communication. Further case studies will include also the relatively remote district-level centres which as many of the foreign museum professionals who have worked with NCSM have argued, are often more innovative with their engagement and outreach programmes.

Another issue that I have presented very briefly, in the second chapter, which requires in-depth research and analysis, is the flow of funds from the Ministry of Culture to NCSM, and subsequently to the district-level centres. There is not much clarity in the public documents of NCSM regarding the exact allocations for projects and activities, which is a little surprising, because it is a public institution. In its annual Activity Reports, monetary allocations are not mentioned (that information is available on the Ministry of Culture's website). It would also be important to note here that during my fieldwork in Kolkata, when I interviewed multiple NCSM officials, my focus was to understand the goals, objectives, activities and the structure of this complex institution, and I did not focus as much on funding. This will be rectified in further research. Another significant consideration regarding funding is the issue of government control over the rhetoric and activities of NCSM. While all the interviewed officials were largely appreciative of government efforts to fund the cause of informal science education, it is worth remembering that the NCSM is almost exclusively dependent on government money for its existence. Does it mean that the central government has an overtly strong voice in the activities and the path pursued by

[121] I briefly addressed the issue of public opinion in Chapter 3 where I carried a section with the analysis of a public survey done by NCSM to gauge public responses to BITM's galleries. It was a significant amount of data, and it helped us understand that the BITM is largely appreciated by the public. However, in the future, I would like to carry out intensive studies of the galleries and in-depth, semi-structured interviews with the visitors.

NCSM? This question, while difficult to find responses to, is still worth asking in the future.

Finally, one last time, I will return to the phrase 'scientific temper', because it has emerged as the strongest recurring theme in the dissertation, and I argue that in future research, it could prove to be a potential discursive force in interpreting science-technology-society relationships in India. Much of the discussion in Public Understanding of Science and science communication debates has used the framework provided by the 1985 Bodmer Report of the Royal Society, UK which prescribed educating the (lay) public assuming that they were scientifically illiterate; and by the 2000 House of Lords Report, 'Science and Society' which criticized the 'deficit model' of the previous report and suggested that a two-way communication process between scientists and the public had to be developed so that the latter's voice could be heard as well. Recently, however, scholars have argued that there exist multiple histories of science communication that go beyond these 'deficit' and 'dialogue' models (Davies and Horst, 2016). Following this claim, I argue that Indian science policy makers have adopted a different approach to science communication—the promotion of 'scientific temper'—which focuses on the citizens as parts of a transformative society where their contribution is fundamental to the nation-building process, and hence their individual participation is crucial to ensure effective public understanding of science. The promotion of scientific temper hinges on the assumption that Indian citizens will perform their constitutional (even moral) duty of inculcating scientific temper. With cognate concepts like 'grassroots innovation' (explained in some detail in the second and third chapters), we move a step ahead of scientific temper, as it assumes that every individual has the capacity to innovate. With the communication of a concept like 'grassroots innovation' could we say that the proverbial wall between science/scientists and the public is finally starting to fall apart? To answer this question, we need to be able to listen to many voices from the public. And finally, on a cautionary note, while scientific temper is indeed an important legacy of independent, post-colonial India, it also has had a strong political origin. Jawaharlal Nehru was not only the first Prime Minister of independent India, he continues to be regarded as one of the stalwarts of the Congress (political) party. In India's chaotic democracy, could a phrase attributed to Nehru continue to play a significant role in the society? Or does it run the risk of political

(mis)appropriation? Hopefully, with further academic attention, the solutions to these questions will appear with further clarity.

Transcript of interviews[122]

Interview with Ganga Rautela, previous Director-General of NCSM (in office at the time the interview was carried out in July 2015)

How crucial is the term 'scientific temper' in determining the activities of the council? Can it be considered a part of independent India's scientific legacy?

The development of scientific temper has been one of the primary objectives of the council. It has also been a government priority and has been given importance in every successive science policies of the government. One could also say that development of scientific temper has been one of the main objectives of independent India's science and technology programme, because it was felt by the leadership that a scientific bent of mind is necessary for acknowledging and accepting the importance of science and technology for national growth and development as well as for adopting logical approach in every spehre of daily activities.

Though India has had a glorious past in science and technology, it definitely got impeded during the British rule, which was a period where the development of indigenous technologies and processes took a backseat. The focus at that time was on imposing British technology and goods as well as British education methodology. After independence, science and technology were considered as the main vehicles of national development. And because India already had well developed scientific traditions at its disposal, it was able to adopt new practices quickly and support the scientific programme in the country. For example, our strong base in Maths led to rapid development in the information technology sector.

In the aims and objectives mentioned in the Memorandum of agreement (of 2014/15) with the Ministry of Culture, the promotion of India's scientific heritage is mentioned. Since when has this been perceived as a major objective? What are the actions being taken in this regard?

There are a number of types of projects planned for this. They include creation of new exhibition halls dedicated to Indian scientific heritage, special publications on this issue and conceptualising fresh travelling exhibitions (like one which was taken to Trinidad and

[122] It is to be noted here that the interviews carried in this section are those for which I have received written approval from the concerned individuals. This is not an exhaustive list of all the interviews I have conducted during my research. The transcribed interviews are also supposed to reflect the questions that were asked to generate these primary source materials.

Tobago recently) as well as documenting and interpreting S&T heritage with modern perspective.

What are the key fields of science being represented in the museums?

What does the council perceive as India's achievements in public understanding of science? As a country, we are definitely fascinated with academic disciplines of science, but what is the level of engagement of the public with scientific facts, technological changes, and issues like climate change to name one?

We have to achieve a lot in this field. Having said that, with government support a lot of effort is being put in by institutions like museums and science centres, and the media to improve public understanding of science. A number of scientists are also participating in these programmes.

Scientific temper is an important phrase also in this context because there are still superstitious beliefs held and practised by the population. So it is important that we are able to disseminate scientific facts without outright ridicule or countering the religious beliefs of the people. There are extensive rural programmes that we carry out, where our aim is to make the people think and come to an understanding through observation and logical deductions.

About management, partners and projects

In the history of the council, which have been the major milestones? And which have been some of the setbacks?

The development of the council itself has been a milestone for us. The first step for this was laid by Dr Bidhan Roy who, after a visit to the Deutsches Museum in Munich, was instrumental in convincing Pt Nehru, our forst Prime Minister to set up the Birla Industrial and Technological Museum in Kolkata to safeguard national scientific heritage aznd portray appropriate technologies for social good. After the setting up of the museum in 1959, attention was turned to other parts of the country, at first towards Bangalore where the first museum, the Visvesvaraya Industrial and Technological Museum was opened in 1965. Both of these comprised collections of artifacts.

In 1975, a new model of science communication inspired by the success of the Exploratorium in San Francisco was adopted in the creation of the Nehru Science Centre in Mumbai. It was designed to be the first science centre, which would then be followed in other parts of the country.

Which are the institutions the council refers to as benchmarks?

The initial benchmarks were the Deutsches Museum, London Science Museum and the Museum of Science and Technology in Chicago. But now that the focus has shifted to the creation of science centres, Exploratorium, the Smithsonian, Ontario Science Centre are some of the major centres we consider as benchmarks and look at as collaborators. One major boost for working together was provided by the Indo US sub-commission, which allows science and tech collaborations and exchange of science museum professionals.

There are a number of institutions in India working for better public engagement with science (Indian Academy of Science, Homi Bhabha Centre for Scientific Education, National Institute of Science, Technology and Development Studies, Vigyan Prasar, National Council for Science and Technology Communication to name a few). Does the council collaborate with them?

All centres under the council have their own advisory committees. Members from some of the institutions mentioned in the question are in these committees. We collaborate on number of activities which have national reach, for example the Total Solar eclipse, Science Film festivals, lecture series etc.

Which are the some of the important current and future projects?

At the moment we have 48 centres. We are developing 21 more. However, the actual demand is a lot more coming from the states. We have taken up development of Innovation Spaces in all science centres to inspire young students to take innovative activities, identify problems and try for solutions; in a way be inventive and adopt discovery approach through hands on activities.

How is the relation between the regional headquarters and satellite units? Is the exchange of knowledge and exhibits a one-way flow from the headquarters to the units?

We have had a conscious model of development and networking. We need to train people in new communication skills. The four regional headquarters function as spaces where the infrastructure is created for expansion. The Central Research and Training Laboratory in Kolkata works as R&D hub for new generation communicatioin tools and exhibits, training of staff and international collaboration.All big centres collaborate with each other for massive expansion programme of science centres.

How tied is the council to the Ministry of Culture in matters of decision making?

The council has autonomy. But the governing body of the council is appointed by the government. The role of the government is mainly related to finances and approval of new projects and schemes. Ministry is the primary source of funding.

About visitors

What is the present scenario related to visitor footfalls? What are the strategies to improve visitor attendance?

We fare very well when compared to other museums in India. We have registered about 10% growth every year.

We depend on advertisements, circulars, directives, media coverage and mainly word of mouth for visitor footfalls. This needs visitor care and satisfaction factor very high. Therefore, maintaining of exhibits, facilities and addition of new facilities and activities is key to this.

What is the percentage of school children among the visitors?

The all India average is about 25%. But in places like the Birla Industrial and Technological Museum or the Regional Science Centre in Kerala it can go as high as 70 to 75%.

Is there any research done on the economic capabilities of the visitors: which economic/social group do they belong to? People from the higher classes in India have better access to scientific knowledge, which others sadly cannot afford. Is the council also committed to play a social role in bridging the class divide which creates obvious chasms in terms of procured knowledge?

Each centre does regular visitor surveys to understand segments that are coming or not coming to the museums. There are special ticket prices for below poverty line visitors as well to encourage them to visit. Science centres adopt inclusive approach to engage almost segments of society into the science communicatio programmes of the these centres.

What are the language strategies of the museum for its displays? How do they differ in different parts of the country?

We follow a two-language formula. English is constant alongside the local language of that place.

About objects and the act of curating

Which are the branches of science and technology most represented in the museum? What is the reason for the choices?

Almost all centres have a fun science section which present exhibits to attract, excite and engage visitors, specially students. Science Matters- which are important to India like energy, climate change and water are also addressed quite extensively. India's heritage in science and technology is also explored. As physical science exhibits are easier to create and make them participatory, almost all centres have galleries on them.

Every centre also has special exhibitions on themes relevant to that area, because of the presence of other scientific and technical institutes or a local tech industry. Bangalore has an exhibit on space technology, Mumbai has one on nuclear power and the biodiversity rich zone Mangalore has one on biodiversity.

How much do school science syllabuses influence curatorial choices, especially in terms of new installations? Do you work closely with schools or school boards, given that informal education for school children is one of the most important activities for the council and its constituent museums?

The school science syllabus is important for the council, as one of the objectives is to improve and provide support for the STEM programme. We also have curriculum based exhibits and kits available in the mobile science exhibitions.

Which are the areas of science and technology which are being considered for future exhibits in the museums?

Frontier areas of science and technology: nanotechnology, space science, new materials, climate change, Information Technology etc. Current needs of the country will also be addressed: health, nutrition, energy, climate change, water etc.

Would you say that the council's predominant focus is children and young adults given that the permanent exhibits are mainly geared towards education?

Children and young learners definitely constitute one of our key target groups. But they are not the only focus.

What do you perceive as the biggest limitation of science museums in India with respect to objects?

Collection management, storage and conservation. At times, it has also been seen that it is difficult to determine and establish the source of certain objects.

What is the reason behind starting mobile science exhibitions? Do they mainly focus on current scientific events?

Because we have not been able to reach to vast Indian population in rural areas and expand fast enough, and not able to reach as many people who cannot come to the cities. The programme started in 1965 and we run 23 mobile units which reach to over 2.5 million people specially school students.

Financials

Which are the main sources of revenue of the council? What is the percentage derived from the Ministry?

There is public money from the centre and the state governments and then also some money which we draw from sponsors. The government funds the new science centres. However, for our own running costs, we generate about 46%.

Which are the main expenses apart from staff salaries?
New programmes and facilities, development of exhibits and maintenance.

Is it possible to revise budgets in case any of the museums want to put up a new exhibition?
For extra funds, proposals are sent to the government. Generally we are able to receive the required sum.

Interview with Samarendra Kumar, Director (NCSM Headquarters, Kolkata); carried out in July 2015

Given that most of the science museums under the NCSM can be classified as science centres, I am trying to understand the breadth and scope of science museums in India. What would you say are the different types?

The NCSM has under its ambit two of the prominent scientific and industrial museums (examples are the BITM and VITM). Then of course there are the science centres under the control of NCSM, Science Centres developed by NCSM and handed over to states and Science centres and Tech. museums under the control of State govt. & Pvt. Institutions such as Birla Museum, Pilani. A number of universities also have collections of science as can be seen in the case of the Birla Museum of Pilani. Zoos and Planetaria also come under the definition of non-formal science education centres. Then there are multiple important museums with extensive collections in their natural history sections, like the Indian Museum in Kolkata which houses archaeological artefacts. There are also special museums like the Railways and Toilet Museums in Delhi which are focused on a specific topic. One can also include institutional museums like the State Bank Museum (of the most important public bank in India, State Bank of India) in this list.

The NCSM under its own ambit has multiple centres. How many centres are there? Could you explain the structure a bit more in detail?

The NCSM currently has about 25 science centres, including the headquarters and the Central Research and Training Laboratory (which is in charge of training the human

resource, R&D for display and design, conceptualizing and fabricating exhibitions and displays as well as providing infrastructural know-how to all the other museums). Apart from these, the NCSM also developed a no. of new centres in different regions (in the constituent states and union territories of India) and then handed over their administration to the governments of those regions. The decision to do so was taken around 2001, when the Ministry of Culture (under which the NCSM functions) realized that it was not possible for the NCSM, with available manpower, to manage all the new institutions which were being set up, given that the government suggested that each state and union territory should have science centres (at present there are 28 states and 7 union territories).

Of the science centres that the NCSM controls, there is a hierarchy in the management. The headquarters of the NCSM located in Kolkata is the central administrative unit. Under the NCSM are the national level centres (located in some of the most important metropolitan cities in India). These are also the zonal headquarters and are responsible for coordinating the activities of the regional centres (which are located in various state capitals), and district-level/sub regional centres.

Does the NCSM manage the activities of all the centres? Also, are there other science museums and centres in India which are not part of the NCSM?

NCSM is the apex body for all the science centres which come under its rubric. However the four zonal headquarters (North-Delhi, East-Kolkata, West-Mumbai and South-Bengaluru) coordinate the activities of the centres under their administration. The Central Research and Training Laboratory (located at the headquarters) provide training for the human resources required to run the organization, and also all its infrastructural needs. Science City, Kolkata is the fully self-sufficient centre under NCSM headed by a Director.

Regarding the second question, there are other science museums especially in the southern states of Kerala and Tamil Nadu. However, NCSM because of its knowhow and significant experience in the field is the most important such institution in India. It supports these museums & science centres by providing catalytic support. All the new science centres are currently being developed by NCSM (about 17 which will then be handed over to the states).

Comment on the visitors to the various centres of NCSM. Who are they? Are they mainly from schools and educational institutions? What are your strategies to gain more visitors?

We have two categories of visitors: the ones who visit the various museums and centres and those who participate in the outreach programmes (this number is about 15.07 million in a year). A great number of visitors to the museums comprise school and college groups. Certain boards of education (Delhi board, for example) include a compulsory visit to the science centre as part of the school curriculum. We also have our own database of schools and undergraduate colleges which is regularly updated, and circulars and notifications of activities are sent out to them. However, we do not only cater to students, as is evident from our extensive outreach activities for various social groups like housewives, parents, differently abled people.

Further to these museum visits, the NCSM along with multiple other state and central government institutions organizes science fairs, seminars, drama competitions specifically aimed at school children across the country to promote public engagement with science. We also offer special training programmes for teachers and have also developed educational kits (like CDs) for various scientific disciplines which teachers can take with them for teaching in their schools. We also have extension activities for the rural population in the form of the Mobile Science Exhibitions which covers almost 2.5 million rural children.

Another very important facility which NCSM is setting up in Science centres/museums all over India is the Innovation hub. These innovation hubs are being set up with an objective to encourage young children in doing innovative activities in the hub with the lab like facility available and nurture their creative talent. The Innovation hubs are trying to promote culture of Innovation and engagement in Science amongst the youth of the country.

Regarding attracting more visitors, work is on to provide better digital interfaces and websites for all the constituent museums and centres, and also to provide virtual galleries for the visitors. We have taken active interest in promoting our work through social media.

One question about funding. While the budget of NCSM is approved by the Ministry of Culture, Government of India, do you also have plans to raise extra funds?

Apart from central government funding, we also receive money from state governments/organizations for specific programmes. NCSM also earns revenue from offering consultancy services to other organizations (for example setting up a new museum, gallery) and this is about 20% of the project fee. For science fairs, science seminars, we receive private sponsorships as many organizations are interested in scouting talents through these. Also, at times when exhibitions travel abroad, costs are covered by the host museum. Extra revenue is also generated from license fees for some of the services such

as catering, operation of souvenir counters etc. These additional funds are generated to meet our non-plan expenditure which has been increasing on year to year basis.

Interview with Dr Emdadul Islam, Director, Birla Industrial and Technological Museum, Kolkata; carried out in July 2015

The interview with Dr Islam was carried out over the course of two weeks. Multiple issues were discussed. Below are excerpts from some of the main topics that were covered.

On the causes of the inception of BITM

The BITM which was inaugurated on 2nd May, 1959 could be considered the birthplace of the Indian science museum movement. It was the brainchild of Dr Bidhan Roy, then Chief Minister of West Bengal, who after visiting the renowned science museums of Europe like the Science Museum, London and Deutsches Museum, Munich was inspired to create a similar institution in Kolkata. Once he returned from Europe, he discussed with Nehru the importance of preserving industrial and scientific heritage, that the European museums had done remarkably. Furthermore, Dr Roy was preoccupied with the general apathy of the public towards technology. To assuage the fear of technology, he felt the need to encourage young people, and for that the museum would be a very good starting point.

There was yet another reason why the science museum was perceived to be an important institution in India. After the country attained independence, there was a deep political will to improve the living conditions of large swathes of the Indian population: to uplift them from poverty, to build necessary infrastructure, to provide education. The promotion of science and technology was seen as the only way out of social problems. Additionally, the need was felt in the corridors of power to focus on home-grown technologies instead of importing them as in the long run this would be the more sustainable method to keep up the drive for development. And in this pursuit for development, the population also had to be convinced that it was for their good. While there were existing technical institutions of excellence in cities like Calcutta, Bombay and Madras, in the 50s (the first decade following independence), not many people had access to modern technological education and knowledge. This was perceived as a major drawback which needed to be addressed immediately, by ensuring universal awareness of science and technology. Science museums were perceived as institutions which were best suited for this purpose. All these aforementioned reasons were responsible for the creation of the BITM, with Nehru approving Dr Roy's proposal for the construction of the first public science museum in India.

With the approval, Dr Roy approached GD Birla, one of the pre-eminent industrialists of the time. Birla readily agreed to donate part of his property (residence and plot) to this cause on one condition: that the new institution had to be a museum of science and industry, with focus on the application of technology. Hence the name Birla Industrial and Technological Museum. Another important historical fact that deserves special mention in the story of BITM is Dr Roy's extensive involvement in the creation of the galleries of the museum. Amalendu Bose, who was the main officer for this project used to visit Dr Roy's office every week to take notes on European museums and his vision for the upcoming Indian one. These stories clearly show the passion of the first nation builders for the science museum movement.

On the issue of designing galleries and the processes involved in creating them

In India, unfortunately, we don't have landmark collections. Most prototypes of important inventions are in the US and Europe. In the early days of the museum, the curators were interested in collecting industrial relics and artifacts which were of importance to India. However, they felt soon enough was that there was not much available for display. It was then that they decided to create replicas, using the services of local craftsmen. With help from London and Munich, exact replicas of machinery were built and the best part was that they could be working models. The role of craftsmen especially in the initial days of gallery formation cannot be overstated.

With the opening of the Exploratorium in 1969, the science centre approach gained a lot of popularity in India. The best aspect according to Indian science museum professionals was that with this new approach, the museums could now create its own objects for the teaching of science and technology. With the success of the Exploratorium, all the following science popularisation initiatives of the government adopted this model. Science centre was also preferred as the focus was on educating the youth through engaging activities and hands-on experience, supplementing what they learnt in schools.

The BITM as it is today is a mixed museum, incorporating features of both science museums and centres. Its focus is on school students and concept building in science. We want our children to be active participants in the scientific culture of the country. Science should be fun, technology a hobby, and not just professions. Some of our galleries like Mathematics, Biotechnology and Metals are designed keeping in mind the school curriculum, as schools are our major clients, and they bring children for the learning experience. As we want students to actively pursue science in the future, focusing on basics to dispel the fear of Maths (as has been revealed by surveys) and sciences in general, is necessary.

The construction of a gallery is a long process. Galleries first and foremost are stories. Curators conceptualise the content around the story that they want to tell. After the conceptualising, curators discuss the project with exhibition officers. The officers prepare dummies of the exhibits (Earlier this was done with cardboards with a 1:25 scale). The team which approves the gallery design includes curators (with background in natural sciences, engineering and technology), exhibition officers (art students from different art colleges). Depending on what kind of displays there will be, electronics and computer engineers are then involved in the production process. Sometimes education officers also offer their feedback, as they are the intermediaries between the museum and the public. Finally, every new exhibition is vetted by the zonal director (in this case, the Director of BITM). Often, professionals from the satellite units are also called in for consultation. At times, however, for the creation of certain galleries, expert committees are formed, as in the case of the Biotechnology gallery.

As BITM is a science education resource centre, our focus is predominantly on science education. This is why the focus of the galleries is to deal with concepts which the student community would find useful. In some cases, like the Mathematics gallery, the design is such that teachers can offer lessons in the galleries. We also have some new projects in the pipeline: one of the future galleries will be on modern biology, which will showcase the frontiers of biology. A laboratory will be established within the next year to accompany this gallery which will come up in another two to three years. Focus on biology is also reflective of the advancements Indians have made in the fields of genomics and pharmaceuticals. In the USA, there are many Indians who are doing cutting edge research in these fields, and hence we want to bring this knowledge to more young students, as many schools cannot have modern biotech labs. Another project which we are planning to start is to create a collections-based gallery for which private collectors will be invited to showcase their personal collections.

On BITM's role as the zonal headquarter of the eastern region

BITM has eight centres under its control (also called satellite units) as it is the national level centre and the zonal headquarter of the east zone[1]. However, all new activities for satellite units are proposed by individual centre heads. Thus, it is not the headquarter which dictates new projects to the satellite units. For example, the centre head of the Bhubaneshwar Science Centre in Odisha (another east zone state) creates the annual plan. After the plan is created, there is a meeting with of the director of the zone, finance officers, civil engineers (in charge of building and maintenance), centre heads and a headquarter coordinator from the BITM to discuss budgets and plan feasibility. Each centre's budget comes to the BITM, and then from the headquarters, a very detailed budget requirement for that zone is drawn. Each zone also has its own executive committee (parallel to the governing body for the Council), which discusses the budget (alongside the financial

advisory committee) before passing on to the governing body. Finally, once the governing body approves, the budget is delivered to the Ministry of Culture, which is then passed on to the Finance Ministry and finally to the Parliament. The approval of the budget comes from the government. Here it must also be mentioned that most of the administrative support for the satellite units comes from the headquarters. The regional level and district level centres (satellite units) have their own heads, but primarily they are in charge of education programs in their respective areas, and the fabrication and maintenance of their galleries. This is reflected in the staff composition as well. However, as mentioned earlier, the preliminary plan is drawn by each satellite unit, which is then sent to headquarters where the plan is finalised before moving higher up the hierarchical ladder. Thus, while the funding comes directly from the government, the decision-making process is anything but top down.

On public understanding and engagement with science and the role of BITM

We have a lot to achieve in the field of public engagement with science. As of now we have about 95 science museums (including centres, planetaria and zoo) for a population of 1.25 billion people. In India, not only do we have a vast population but also challenges related to its vast geographical, regional and linguistic diversity. We also believe that public understanding of science is not easy, and understanding of specialised branches of knowledge cannot be achieved solely through informal training. Hence our focus is on public engagement, which allows us to develop activities with which we can have dialogues with people, and promote the notion that science is fun. One of our main methods of engagement is the Mobile Science Exhibition, which are very popular in the rural areas. There are about 25 buses nationally, and the BITM itself has 2 buses. These travelling buses with science exhibits often address issues like superstitious beliefs for which we have dramatic programmes like ‘Science magic and miracle shows’, so that their concepts of miracle get demystified. For such issues, we believe there needs to be a sustained campaign and we need to keep visiting the rural population with new offerings. Every year as of now we have two new travelling exhibitions. In a way, these mobile exhibitions are also more dynamic as it is easier to change their content as opposed to the galleries in the museums. The buses carry 24 exhibits on various topics related to science in everyday society. Our aim is not exactly to provide scientific literacy, especially given the vast chasms of knowledge people have and also other social issues that continue to plague them especially illiteracy. But we want to promote scientific temper, or a more rational way of thinking. In a way, we want to provide the people with another point of view, another window from which they can see the world differently. However, especially for what concerns engagement of the rural population we will require greater synergies with other public institutions.

On displaying scientific and technological heritage in India in the galleries and on scientific temper

With the focus on creating science centres and providing an avenue to students to learn how science is done, the heritage of Indian science and technology has taken a backseat. However, there are specific galleries devoted to this topic at the Delhi and Mumbai science centres and a new gallery is coming up in Science City in Kolkata. In some of our galleries we have woven in stories of Indian ingenuity like the Mathematics and the Transportation galleries. We must admit that the Indian heritage in science and technology has not been well documented. However, we have done a special travelling exhibition (not one of the Mobile Science Exhibitions) which toured in the USA and Trinidad. We also need to find ways of interpreting old religious texts as well because there are gems of astronomical observations and mathematics to be found in some of them.

What we are definitely interested in promoting is science as culture through the concept of scientific temper. We want to communicate the idea that science is not just a set of rules and knowledge, but it is a way of thinking, of doing things. A person with scientific temper would be willing to receive inputs from everywhere without perception bias. It is of course difficult to cultivate it, nevertheless we have to try to inculcate the values of scientific and rational thinking among our youth and the rural population.

Interview with Dileep Ghosh, Education Officer, BITM; carried out in July 2015

In this discussion, Mr Ghosh explained the various activities that the BITM carries out for educational purposes, and the alliances, partnerships they have in order to deliver an all-round educational experience to students. He commented in detail on the various extension activities that the museum has in place in order to follow the mandate of promotion of scientific temper among various demographic groups.

We have a number of tie-ups with schools for our extension activities. Schools can choose to be institutional members of our museum. This allows them to also bring as many students for a visit on a single day. The science demonstration lectures that we carry out everyday at specific hours are also free for members. Lectures are carried out by science communicators and they are based on existing school curriculum. Schools can also choose the topic on which the lecture is to be delivered. These lectures are also a good place for students to see the experiments that they study about in their books.

Another major activity of the NCSM is the science drama competition. Ghosh explained further regarding this and other outreach activities.

The science drama competition is held at multiple levels before it reaches the national platform. The first competition takes place at the district level. The winners of this level enter into the state level competition. After this, there is the zonal competition and finally the national. The broad topic for 2015 is 'Science and society'. Students are expected to interpret this theme and present an original skit.

Apart from the drama competitions, we also have science fairs. In this case students are expected to create their own projects and present them. For this, we have multiple state-level partners who act as coordinators, namely the SCERTs (State Council of Education and Research Training), DSTs (Department of Science and Technology). Private companies also provide crucial patronage to those projects which have international potential.

The third activity that we carry out which is another national level competition for students is the science seminar. Since 2015 is the International Year of Optics, this year the theme is harnessing light. The finances of the seminars come directly from the NCSM. The government arms of the state of West Bengal related to education and research like SCERTs, DSTs, Youth Service Department are also active for coordination purposes of this event. Students are expected to present five slides, more specifically to create a simple and effective presentation and then carry out a discussion with a panel of judges.

On rural outreach programmes.

Apart from these numerous outreach activities, the museum is also committed to aiding the Sarva Siksha Mission (Education for all mission) of the central government, especially with training related to computer-aided learning. This involves training school teachers to use digital resources and also to create their own materials. In West Bengal, about 3500 schools have been covered in three years. Three to four teachers from these schools come for the training.

The mobile science exhibitions (MSEs) constitute the other important activity of the BITM. The museum itself has two buses; and three other district units which are under the museum have one bus each. These units are Burdwan Science Centre, District Science Centre, Purulia and North Bengal Science Centre, Siliguri. The Digha Science Centre which is also under the BITM is the only one without its own MSE bus. This is primarily because the MSEs move in schools and are hosted there for a few days while the exhibition is open to the local population. The MSEs include science shows, demonstration lectures, school science quizzes and film shows.

About some of the key issues in science communication in India

One of the main problems is which language to communicate in. There has been a demand for Hindi explanations and labels in the permanent galleries of the museum (right now they are available in English and Bengali).

Another issue is the diversity in demographics of the visitors. Modern science communication is all about story- telling and to pitch the story correctly, we need to know our audience. So, where we start the narration depends on what kind of audience we are addressing. There is very deep seated superstition among many sections of the population. At times we have to use it as an anchor to tell a story, instead of alienating the audiences. However, these are definite challenges which we have to rise up to.

Interview with Bernard Finn, Curator Emeritus of the Electricity Division at the Smithsonian Institution's National Museum of American History (long-term collaborator with Saroj Ghose and NCSM); responses received via email in July 2016

Is there any other institution in the world which you would consider a parallel model of science communication? Do you think the NCSM has a comprehensive and transferable system for the promotion of scientific knowledge and thinking which could be useful in countries with similar economic and social trajectories of growth and development?

The NCSM is highly unusual, especially among museums, and most particularly as a government-sponsored effort. Science centers elsewhere are loosely organized (ASTEC, ECSITE, CIMUSET, etc.) in ways that encourage exchange of ideas, but they do not have centralized programs. Individual museums (and occasionally partnerships) have developed exhibits that are made available to others (for a fee)—notably the Exploratorium and the Smithsonian's Traveling Exhibit Service . The Smithsonian has NSRC (National Science Resource Center) which has had modest success in the development of hands-on classroom activities nationwide. The Science Museum (London) and Deutsches Museum, among others, have effective outreach programs. And a number of impressive operations promoting what is now commonly called STEM have appeared. But none of these has the scope of the NCSM.

Before exporting the model there should be an objective study of its effectiveness, which is not easily done. Number of visitors to museums/centers (including ages and average length of stay) is one measure—especially large vs. small centers vs. science cities. Likewise for traveling exhibits and other programs. What did they look at and (difficult to

evaluate) what did they learn. What is the relationship with schools? Were there any special factors that made for success? Are these factors unique to India? And so forth.

Going back to the early days when the creation of NCSM was being discussed, do you think the then Indian government, science policy makers and museum professionals were responding in any way to the global shift towards public understanding and engagement with science? Is that the reason why they chose the science centre as a preferred model for science communication?

I don't know enough to say with any degree of certainty. I think it is fair to assume that interest in science centers was influenced by developments in other countries. One can see this in the origins of the Birla museum and later in the ways the nascent NCSM reached out to foreign experts. My impression was that the way things happened was largely a product of the personalities of Bose in establishing the seed museums and of Ghose in expanding into a national network with a broader view of programs and activities.

What were the reasons which interested the Smithsonian to participate in the development of the NCSM? Or was it your personal association with Saroj Ghose, the first Director-General of NCSM, that led to further exchanges?

Totally happenstance. Ghose contacted me as he was completing his studies at MIT because I was curator of electrical collections) and spent some three months at the Smithsonian. He later returned to pursue his PhD, and I quite naturally became interested in his plans. At the same time (and without, as I recall, any specific input from me) he began to make use of the still-available PL-480 funds, which were administered by the Smithsonian, to fund workshops in India. Various interactions (my trips to India, the group that came to Washington in 1988 or '89, etc.) involved personal initiatives by me, considered appropriate by my supervisors. The agreement that led to the current program in science communications has similar foundations. I might add that this is not unusual at the Smithsonian. Curators have a great deal of autonomy in pursuing low-cost ventures; and if they are successful funds are often available if needed.

You have visited multiple centres under NCSM. With your vast curatorial experience, what do you think of the content, especially the descriptions of science and technology on display at the centres? Do these museums cater to a specific audience in your opinion?

More than in this country the goal (as it was explained to me) was to cater to a broad audience, including adults, because so large a portion of the population had not had exposure to scientific and technological developments, and the exhibits reflected that. The

situation has almost certainly changed, and it would be interesting to analyze the effects on museum programs, which I am not in a position to do.

Regarding content, I was from the beginning impressed by the imaginative and innovative ways exhibits and other programs had adapted and altered what was learned from the West. Example include, in no particular order: the large rolling-balls display in several museums; outdoor exhibits; science fairs, and especially bringing winners of local fairs to a central location; quiz shows; the traveling bus exhibits; and the incredible science cities. From the beginning I was impressed with the quality of design in the exhibits—clearly a reflection of special Indian talent.

If there is a real possibility of a two-way extensive knowledge transfer between the Smithsonian and NCSM, what are the things that these two institutions can learn from each other today?

Cross-cultural interactions are almost invariably a positive influence on both parties. Certainly my involvement with the NCSM has been invaluable to me—personally and professionally. Basically one discovers that learning is culturally driven; what works in one place may not be effective in another. On the other hand, practices developed independently in one place may stimulate ideas that can be fruit fully applied in another. For these reasons I regret that over the years there weren't more opportunities for younger curators to visit and spend significant time in the other country's facilities. It's hard to be specific; there are so many things to discover.

Interview with Robert Friedel (Professor of History at the University of Maryland, College Park with long-term experience in collaborating with NCSM, especially on their Master's level course on Science Communication); responses received via email in October 2015)

In the traditional science museum space, historicity of objects is a crucial point of carrying forward the narrative of progress and the role of the nation in it. From your experience with the National Council of Science Museums (NCSM hereafter), would you say that it is the same in the case of India?

The narrative of progress, as I've observed it, is different in Indian science centers. The differences are hard to describe, but I believe they derive from a couple of key factors: (1) the belief that modern sci. & tech. are key to India's future and that the country is behind in making use of it and needs to catch up and (2) the "nationalist" agenda that is behind much Indian government cultural effort – a continuing response to the imperialist heritage.

In an interview with one of the directors from the NCSM, I asked the question: why is there so much attention paid (by way of displays) to science which has originated in the west? To this, he said that the idea that science is western is hegemonic and something that he doesn't subscribe to. What are your thoughts on this issue? Are we looking at a particular space in time where science is being decolonised for greater public consumption around the globe?

I've thought a lot about this, since I interpreted my job at the NCSM as teaching the foundations and historical change of Western science, leaving discussions of Indian science to other instructors. My own take on this is that science is not "Western" in some abstract since, but as a historical product the science that we actually teach students (and museum goers) largely (not exclusively) originated in Europe and North America. When I teach the history of science and technology to NCSM curators, I acknowledge that I am only teaching the "Western" aspect of it – but I argue that this is the largest proportion of what they are actually trying to convey in their own exhibits.

I am not sufficiently familiar with the jargon of hegemony and decolonization to know how to frame these issues in that language, but I'm certainly aware of the questions they raise about the history of science in the Indian context (or in any "non-Western" or post-imperialist context). I think it is most effective, at least for our publics, to go with the idea that science, at some level, is culturally neutral. This is, I think, the general message conveyed in NCSM exhibits and demonstrations. This is a great topic for further discussion, and I'd like to know your own thoughts on the subject.

Another issue that has come up several times in my research is one about lack of objects to display, as is the case with many Indian science museums (and not always because there is a dearth of objects but often there are also bureaucratic hassles and the unwillingness to recognise something as valuable to the heritage). How does one display object-less heritage in museums? How can scientific principles be communicated with minimum objects?

I actually think the science centers have been very good about addressing heritage with a minimum of objects (some of the Centers, of course, have no shortage – Kolkata and Bangalore come to mind). This is done in two important and related ways. A strong use of graphics is important in almost everything that NCSM centers do, and these often incorporate heritage elements. In addition, I've been very impressed by the centers' use of local heritage and traditions. A couple of examples that spring to mind are the centers in Bhubaneswar and Kurukshetra, where local traditions (typically with religious elements) are recruited for science center purposes. In Bhubaneswar, for example, special attention is given to the sun and solar astronomy, due to long traditions of sun oriented worship (as I understood it).

Another key aspect of your question is to acknowledge the skill and ingenuity of NCSM staff in constructing models, replicas, and demonstrations that do not need objects beyond those that can be designed and constructed in NCSM shops.

Since we talk about the history of science, could we extend the phrase to 'heritage of science'? Heritage, especially taking into consideration definitions of UNESCO, is something that has universal value. Could we argue that heritage of science could balance the narrative of history of science which is predominantly western?

I'm not sure that I understand the special meaning you are attaching to the term "heritage" in this question. If this is taken to refer to artifacts (and, presumably, sites) that have connection with the history of science, and if you mean that heritage in this sense could be used to provide a localized interpretation of science when that is otherwise difficult, then I very much agree. India has spectacular examples of this in the Mugul obserservatories to be found in a number of locations. It could be argued, however, that the actual use of these observatories for science education is not well done (although my information is not particularly current or extensive in this regard). One could imagine much more thorough and engaging interpretations of these observatories to link India's scientific past with more modern concerns and history.

In STS literature, the phrases public understanding of science and public participation in science come up frequently when discussing frameworks for better scientific engagement with the public. But from my readings what has become apparent is the tacit understanding that scholars have regarding a certain measurable gap of knowledge that scientists and non-scientists have which needs to be bridged. However, when we look at contexts like India with much greater demographic variations in terms of access to knowledge, how do we use the existing theoretical frameworks for analysis? It is not just that there is a gap, but often there are individuals with little or no understanding of academic science. On the other hand she/he could be a farmer with intrinsic knowledge of natural phenomenon. How can we as historians and social scientists address our own bias when talking about complex interactions like those happen in science museums, especially in India, which cater to very large demographic sections?

Wow! What a question! I don't not see myself as particularly well informed on current terminology or debates in STS, but I think you ask one of the questions that really needs to be asked about STS in the Indian context (and that rarely gets addressed). The answers to this are going to be complicated and will depend on a variety of particular circumstances. Let me make some observations—

(1) One of the key elements at work in the NCSM, in Indian academic settings, and in government is a privileging of "academic science" over other forms of knowledge. This is of course not special to India, but I think your question hints at some of the problems that such privileging may give rise to. We need to recognize, however, that this privileging is, in many ways, one of the motivating elements behind the government's support for the NCSM and the status that it has in both the central and in the state governments. If we were to argue that other forms of knowledge are "just as useful" or some other formulation, this could bring into question this status.

(2) You are quite right that most of the existing frames of analysis that one finds in STS don't work completely comfortably in the India setting. One repsonse to this is the effort to integrate some other approaches, such as subaltern studies, that are more tailored to some of the special problems of post-imperial states. There have been some good efforts in this regard, but I'm not well informed on how these efforts have been received in India or if any effort has been made to craft actual museum responses based on their findings.

(3) How, indeed, can we address our biases? Most commonly the first step is simply to identify them and to recognize their origins and influence. This requires a rare combination of skills and knowledge, and, if I may, it would appear that you are way ahead of most of us in bringing this to bear on the problem. I look forward very much to hearing your own thinking in this connection.

Interview with Gretchen Jennings, museum consultant and past employee of the Smithsonian (also a long-time collaborator with NCSM on the MSc Science Communication course); responses received via email in September 2016

How would you describe your experience as a teacher of the MS course at NCSM? What did you think of the overall content? What were the topics you discussed? What are your impressions of the students who are receiving this specialised training? Also, are there any other museums or museum clusters in the world which offer such courses for training young people to join this profession?

My experience was very positive. NCSM was very solicitous of our needs and tried to provide for them. The course, which I co-taught with Smithsonian staff member Karen Lee, involved both theory and practice of developing science exhibits that are relevant and engaging to museum visitors to Indian science centers. I am not sure if I sent you the article we wrote that describes the course in detail, but I will do so. In the theory part of the course I taught about research on human learning from a developmental perspective, from childhood to adulthood, and also about research on family learning in museums. Karen taught theory and methods of visitor research. In the practicum part of the course we had

students interview and observe visitors at nearby Science City, and then work on modifying exhibits to make them more visitor friendly.

Yes, certainly in the US there are a number of museum studies and training programs. Also in the UK.

You have mentioned in our previous meeting that you worked extensively at the Science City. Do you consider it to be a good training ground for students of science communication?

Yes, each of the five times Karen and I taught in Kolkata, we pre-arranged with the Director and exhibits staff at Science City to select two individual exhibit components that they felt visitors were not fully engaged with – visitors did not understand how to operate the exhibit or operated it incorrectly, did not read the label copy, stayed only a few seconds at components before moving on. We would then divide our class into two teams, each one focusing on one of the two components. The team would, after the theory part of the course, develop interview questions for visitors, then interview them and observe them at each component. From these interviews and observations the students would draw conclusions about what elements of the component were preventing visitors from engaging and understanding the science principle involved. Then the students, with the help of the central exhibits office at NCSM, would develop new graphics and/or design elements. They would mount these temporarily at Science City and then re-evaluate visitor understanding after the changes to the exhibits. Usually the students would find the visitors did engage with and understand the exhibits more easily due to clearer and simpler language, better graphics, etc. Science City staff have been exceedingly helpful and collaborative each time in selecting exhibits to work on, providing clip boards, pencils etc for visitor research, providing seating for interviews with visitors, etc. We could not have asked for a better venue in which to have the students do the practicum for the course.

The Science City in Kolkata is one of the most visited science centres in India and also in the world. It gets over a million visitors every year. Why do you think it is so successful? What makes it different from other centres you have visited in India? What are the areas where the Science City has to work on further for bettering its own services and offerings to the public?

Of all the major science museums in India that I have visited (Delhi, Birla, Mumbai, Lucknow) I would say Science City stands out in its size and in the very pleasant surrounding gardens and Science Park. I believe that the outdoor area by itself attracts many visitors. Also with its auditorium and convention facilities it attracts large conferences in addition to museum visitors. And I think it has an IMAX theater. I believe

that through all these activities, extending beyond just the museum functions, Science City is able to be self-supporting, or nearly so. The older buildings with older exhibits are in need of renovation, according to my conversations with the Director. It is usually these older exhibits that we work on with the students, seeing how they can be improved. The newer buildings and exhibits (the exhibit on the earth, the new evolution exhibit) are very well done and are strong attractors.

What do you think of the content of science and technology on display in the museums and centres of NCSM? Do you think there is a strong focus on school curriculum of children? Do you notice any presence of Indian science and technology in the displays?

To answer the last question first, yes there are a number of components on Indian science and technology at most museums I've visited. There is a major exhibition on this topic in Delhi, and I remember when it opened a few years ago it attracted world-wide press regarding early Indian inventions in surgery and mathematics.

In my view the components in NCSM museums vary in quality and in science content. Since they are built in a central exhibit office in Kolkata, one sees the same components reproduced in most science centers, depending on their size. Some of these were copied from the Exploratorium in San Francisco, which produced several "Cookbooks" so that their exhibits could be reproduced worldwide. This was in the 1980s or '90s. In my view many of these older exhibits, on tricks of visual perception, are fun and attract visitors, but the science principles they teach don't seem to me to have much relevance to daily life. What I think are the most interesting displays are the ones that relate to local life, industry, etc. For example the exhibits in the Goa Museum on agriculture and fishing. Also the recently opened museum in Dehradun has wonderful exhibits designed by NSCM on the Himalayas, geology, culture, etc. These are beautifully done. One of the exhibit developers told me that they are indeed trying to put into practice some of the ideas that Karen and I have talked about in our classes that will make exhibits more visitor friendly – everyday language instead of complex technical terms; clear instructions; attractive graphics. We have seen this in more recent exhibits.

Regarding the relationship of the exhibits to the school curriculum, I can't say much because I don't know the curriculum. I will say that one of the things Karen and I discussed regarding methods of making exhibits more visitor friendly is that the exhibits and their labels can't just be designed so that only students, experts in physics, math, etc, can understand them. On weekends at Science City entire families visit. In some cases our interviews have shown that some family members can't read. So the exhibits need to be developed so that the design itself helps visitors to know what to do and understand, and

so that families with older adults as well as small children can enjoy them.

Concerning displays, do you think that the district level centres have a distinctly different set of exhibits? Do they cater more to local, rural needs? Do district centres have more social awareness programmes (science in society programmes)?

I don't feel I know enough to generalize. As mentioned above, the centers at Goa and Dehradun seemed to make an effort to address local geography and economy in their exhibits. I'm not sure what they do for public events and programs. I have also visited the small center at Burdwan, and I follow them on Facebook. I don't know what other small centers like this are doing but Burdwan does a great deal on local issues – health of women and girls, water safety, teacher education on computers.

Given that you have visited a number of centres (national, regional and district level), what would you say are the most striking characteristics of the NCSM museums? Are there issues which set them apart from other museums/centres around the world? And which are the areas that require immediate attention?

A most striking aspect is the wide proliferation of science museums. I am not aware of such a network of museums in other parts of the world, but this doesn't mean these don't exist. In the US there is a central membership organization, ASTC, but it does not administer science museums in the country, and does not build them. The role of NCSM in creating this network in such a populous country as India is quite remarkable. If there were such an organization in China, which is the country most often compared to India, I would be surprised. I haven't heard of it. So my guess is that this network is quite unique. It would be wonderful if there could be some kind of nation-wide study to document the impact of NCSM on the introduction of the "scientific temper" of India.

What role do you think NCSM is likely to play in the future given that India's leading role in technology (especially frugal technology, local innovation) is being acknowledged around the world?

I think that NCSM is likely to play an important role. I think it would be extremely important for some agency – maybe the government, or even better, an outside agency since NCSM is a government agency—to do an objective study of the impact of NCSM on the nation. I would imagine the results would show a positive impact, and it would provide a basis for future work by NCSM.

Interview with Walter Staveloz, Director of International Relations at Association of Science-Technology Centers at Washington DC (of which NCSM is a member); interview carried out on Skype in December 2016

What are some of the key activities of ASTC?

ASTC has members from 50 countries, albeit with the majority located in North America (primarily United States and Canada). The institution helps members to build stronger institutions by organising annual conferences, where best practices in the field are shared. ASTC also considers science centres as privileged platforms for science communication and lobbies for their recognition as institutions of importance at the governmental level. International activities include advocacy efforts to ensure that science centres communicate the UN Sustainable Development Goals with special focus on climate change, reducing inequalities and ensuring better public health. ASTC was instrumental in lobbying for an International Science Center and Museum Day, the first of which was celebrated worldwide on the 10th of November in 2016.

In the interviews I have carried out with museum professionals around the world, I have come across varied degrees of differences proposed in different countries regarding what is a science centre and what is a science museum. In India, for example, the distinction is not paid much attention to whereas in Europe, the separation is strong. Academics and professionals from the museum sector are distinct from those working in the science centre field. What are your thoughts on this issue?

I would say that the differences have been decreasing over the years, and in fact, they (centres and museums) have to come together. Science centres are no longer uniquely hands-on places as we want to move away from the push-button environment. Institutions are increasingly creating multidisciplinary exhibits where concepts are presented in a context. Some centres are also trying to bring in objects and live animals, for example. Simultaneously, museums are trying to incorporate hands-on exhibits and activities.

How is the science presented in science centres different from that presented in science museums?

The difference lies in the question of time. Museums with collections present science that is not necessarily current. Centres are more concerned with showcasing contemporary science and technology. Museums have the challenge of making their collections current. However, centres also don't manage to accomplish this always, as research in contemporary science and technology is moving very fast. Also often the most compelling science is not easy to communicate.

There is a major discussion in Science and Technology Studies about issues like citizen science, deliberative democracy and public participation in decision making and governance of science centres and museums. Do you see these discourses getting translated in practice?

We certainly have a different trend today from the earlier deficit model which presumed that the public needs to be taught relevant topics of science and technology. In the late 90s, the discussion moved towards embracing the dialogue model which would ensure a two-way exchange between scientists and non-scientists. However, I would say that we are not exactly in a situation where there is essentially more dialogue. A real dialogue has probably not happened yet, as the scientific community continues to take decisions based on scientific trends as opposed to those observed in public. This topic was also highlighted in one of the plenary discussions of the recently conducted ASTC annual conference.

For participation to be realised to its fullest extent, we have to view the public as one side of the triangle with the scientific community and decision makers taking up the other two sides. We have to inform the public in how decisions are made (and not just facts) and consider visitors as scientific opinion leaders. We have to remember that visitor's attitudes will not change solely because of scientific evidence. I would also like to add here that many other institutions started involving the public in scientific debates before science centres did: namely, zoos, botanical gardens and natural history museums. The question of public participation is extremely important as lack of communication between scientists, policy makers and the public can result in serious problems in the future.

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