Enculturing innovation : Indian engagements with nanotechnology

Summary

The thesis is an outcome of the effort to understand the 'Culture(s) of innovation' in nanoscience and technology (NS&T) research for development in India. The research is qualitative in nature and uses methods such as open-ended interviews, historical analysis and laboratory ethnography that are drawn primarily from sociology and anthropology. It is about a 'culture of innovation' that links the macro with the micro, and what is done within the lab with the world outside – a world that is a much bigger influence than is generally believed.

This dissertation responds to three broad questions with the overall endeavor being to understand the 'cultures of innovation' in nanoscience and technology (NS&T) in India:

1) What is the character of techno-scientific knowledge practices within Indian NS&T laboratories?
2) What is the role of scientific laboratories in processes of innovation in contemporary Indian contexts?
3) How are these to be understood within the broad political, social, cultural and developmental contexts of contemporary India?

Research to answer these questions was conducted in collaboration with five different groups of researchers/scientists involved in NS&T research in different parts of the country – the Centre for Advanced Studies in Materials Science and Solid State Physics, Department of Physics, University of Pune; Centre for Nanobioscience (CNB), Agharkar Research Institute (ARI), Pune; Centre for Nanomaterials, International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI), Hyderabad; the L.V. Prasad Eye Institute, Hyderabad and Sankara Nethralaya, Chennai.

The empirical material is a set of case studies that explore four different contexts, locations and realities of NS&T research and development. Each case study is threaded along what might be considered a particular characteristic of Indian society (see Table 1).

The 1st is the context of economic and material constraints – where a university lab takes the lead in developing indigenous Scanning Tunneling Microscopes in situations of severe resource constraints. Starting in the late 1980s the lead scientist and his students at the Center for Advanced Studies in Materials Science and Solid State Physics at the Department of Physics in the University of Pune, developed a number of scanning probe microscopes by using a range of material and human resources. This included waste materials

Table 1: The structure of the thesis:

Case Study/ The Laboratories	The STM story/Dept of Physics, Pune University,Pune	In a nanobioscience lab/CNB, ARI, Pune	Water filters/ ARCI, Hyderabad	LVPEI, Hyderabad & SN, Chennai/ Retinoblastoma and the girl child
Social context	*Resource constrains*	*Traditional practices and knowledge systems*	*Social exigency*	*Patriarchy*
Scale at which innovation happens	Innovation in the lab at the micro level – lab practices	Innovation in and around the lab at the meso level – organizational, institutional, interdisciplinary	Innovation in and around the lab at the interface with society	Innovation in the lab and simultaneously in society
The conceptual frame	**Technological Jugaad**	**Inter-epistemic collaborations**	**Users matter**	**Reconfigured subjectivities**

from the city's scrap markets, ideas and concepts from the science happening in important centres around the globe, human resources and capacities from local small-scale industry and aspects of traditional knowledge systems as well. Not only did the lab do science that was then published in some of the world's leading peer reviewed journals, it also created a generation of scientists who were very confident and capable of making and working with sophisticated instrumentation. The key conceptual frame that the thesis explores to discuss the work in this lab is technological jugaad, a local variant of bricolage, where innovation is an activity of the commons that involves, among others, the reconfiguring of materiality and recycling of waste in situations of resource constraints.

The 2nd case study highlights the continued relevance of traditional practices and knowledge systems that can be seen in operation in India even today. It is an account from the Centre for Nanobioscience in Pune's Agharkar Research Institute where scientists are attempting to engage nanotechnology with the traditional practice of Ayurveda. The key challenge here for the scientists is to bridge the vast difference in the worldviews as represented by the different knowledge systems of modern science on the one hand and Ayurveda on the other. The nature of the collaboration between the two knowledge systems in not just inter-disciplinary; it can be understood as inter-epistemic. The hierarchy is clear in that modern science is being called upon to validate the traditional knowledge system and yet, the encounter is rich in the possibilities it offers for the reason that diametrically different ways of knowing and understanding the world are being brought together as part of the same conversation.

The 3rd empirical chapter has as it's pivot the issue of the non-availability of clean drinking water for a large section of the people of this country. At the

heart of this story is the effort of scientists at the Hyderabad based International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) to develop a nano-silver based low cost water filter technology that is affordable to even the poorest in society. The scientists were able to develop such an application by innovating upon the existing ceramic candle water filter, but the product was a complete failure in the market. The case study builds upon central concepts in the social construction of technology (SCOT) such as the relevant social group, interpretive flexibility and closure to argue that the users should matter and that, perhaps, the failure of the water filter can be explained by the fact that users were not as central to the technology development, design and marketing process as they should have been.

The 4th empirical chapter highlights the issue of patriarchy and the continued marginalization and neglect of the girl child in contemporary Indian society. This case study revolves around the work of two tertiary eye care centres – L.V. Prasad Eye Institute in Hyderabad and Sankara Nethralaya in Chennai – where a team of clinician-scientists are forced to also become social activists as they seek a nanotechnology based treatment protocol for Retinoblastoma, a cancer of the eye of small children. The bias against the girl child comes centre-stage when parents of the infant girl with the cancer don't seek treatment that will need removal of the eye to save her life. They'd rather let the girl die today because of the fear that tomorrow a one-eyed girl will not be accepted in marriage by anyone. The problem, it emerges, is neither social, nor is it techno-medical; it lies at the intersection of social, the technical and the medical. The patient and her family who comes to the clinic catalyses a significant reconfiguration in the subjectivities of the clinician, who in this case is also the technologist seeking to develop a nanotechnology based protocol for the particular condition.

This empirical material is, in the vast terrain it traverses, also an account of the wide repertoire of sources, resources, people, ideas, materials, instruments and knowledge systems that the labs are mobilizing in multifarious ways. It describes and interprets how people, their technical and social institutions and their combined practices influence and negotiate a particular technology in understanding it, and using it to meet the ends they seek to meet.

Using the learnings from the empirical material and the diversity it points to, the thesis concludes with the following six inter-related steps of how and why innovation is encultured:

a) Innovation is an iterative, non-linear process where differently located social groups and actors, different knowledge systems and different ways of knowing and doing, all play an important role; it does not necessarily start with the producer and end with the consumer and neither does it begin with an invention that is discarded in the end as waste or obsolete

b) Innovation has to be historically and culturally situated, even as we recognise that it endlessly transforms the different cultural logics that bring it into being in the first place
c) The scientific laboratory is an important site of innovation
d) Empirically and conceptually, innovation in the laboratory straddles different domains, and dominant metrics of citations, patents and commercialisation are insufficient to capture the depth, breadth and richness of the innovation processes.
e) Innovation in the laboratory is a multi-scalar process; the three scales that become obvious through the empirical material in the thesis are respectively, i) the micro (within the laboratory), ii) the institutional that gives rise to inter-disciplinarity and iii) the macro where social and cultural processes are inextricably inter-twined with the scientific and the technical.
f) Processes that allow wider participation are more likely to lead to successful innovations, particularly when S&T is being increasingly mandated to find solutions that are directly needed and relevant in society.

Leading on from the enculturing of innovation inside the laboratory there are two salient insights this thesis offers: a) diversities within and between laboratories are reflective of the larger socio-political-cultural milieu within which the Indian S&T system and the labs themselves are located, and b) different cultures of innovation exist in parallel, and acknowledging this multiplicity challenges the idea that only some ways of innovating or only one particular culture of innovation can be successful. The cultures of innovation are characterized as being de-centred in different ways.