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# A Study in the Social-epistemology of "Science and Society" Education at Indian Universities and Technical Institutes

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The field of science and technology education has long been an embattled one for policy makers, educationists and science educators. The discussion has often been mined by an intrinsic tension separating concerns of a liberal education on the one hand and issues of specialisation and vocational education on the other. However, that is only one dimension of the divide. The concern today is as science locates itself more centrally within contemporary life, the idea of the scientification of society more or less reaches completion and the pendulum swings towards the socialization of science [Nowotny et.al., 2001]. Living as we are through a "third industrial revolution" deeply connected with the development of information and communication technology we need to reckon what its impact would be or has been on the world of knowledge production and education. As far as science education or even education in general is concerned this involves negotiating a rapprochement between specialised or local knowledge to global knowledge. In other words the notion of the local plagues science from within inasmuch as it is confronted in its march towards achieving universality of its claims by local and specialised knowledge(s) from a variety of other sources. Such developments catalyze the need to reform not just ways of thinking but more importantly educational and scientific curricula in preparing the next generation of the citizenry. Several educationists have seen the need for this transition in the transformation of cultures of learning into cultures of the learning process. Such a culture, reflexive in nature, could form the basis of a knowledge or cognitive society[1].

## 1. Knowledge forms and institutions

Studies in the social history of knowledge have emphasised that corresponding to every constellation of knowledge there is an institutional form. Since the nineteenth century most of our constellations of knowledge have been anchored within the universities as disciplines [Gulbenkian Commission, 1996]. It is these disciplines which have been in the process of revision, and this revision has more or less precipitated a crisis over the last two decades. `Academic science' manifest in the form of a variety of scientific

[1] See Edgar Morin, "The Reform of Thinking and Education in the Twenty-First Century"; Goéry Delacôte, "Distance Education, New Technologies and New Learning Methods" and Roberto Caneiro, "Lifelong Education and a Curriculum for the Twenty-First Century", in [Bindé, 2001].

disciplines is framed by the social setting of the university [Ziman, 2000]. These universities were geographically and institutionally dispersed. But one feature was that the mechanism for the propagation of disciplinary knowledge was through academics who could transfer between universities and since the 1930s between universities and that new creation of the twentieth century, the research institute. But this migration of academics between universities and research institutes was restricted to mobility within a discipline and not or rarely between disciplines. Thus curricula within universities were very sharply differentiated and structured into disciplines. The current crisis within the domain of higher education manifests itself in the form of the reform of the university and curriculum reform [Felt, 2002]. As the space created within the universities for disciplines is now contested by newer knowledge formations that are multidisciplinary, interdisciplinary or transdisciplinary that are located not just within but organizationally outside the university a new set of questions needs to be asked as to what the new constellations of knowledge would look like in the novel institutional structures that are likely to emerge.

This institutional transformation and the concomitant reconfiguration of the boundaries of knowledge are themselves the product of the rapid evolution of the sciences and social sciences themselves, the changing political economy of the production of knowledge, and certainly a consequence of specialization and institutional differentiation. Within a Luhmanian framework then the eruption of the discourses on inter and transdisciplinarity are but manifestations of the social and cognitive compulsion to reorganize work within the universities. The compulsion arises from the prevalence of unanticipated side-effects produced within highly differentiated subsystems in modern societies. Differentiation itself ensures that each subsystem runs in a highly productive mode, but on the downside the system is rendered incapable of handling the disruption of organic flows between the subsystems that socially manifests itself, for example, in the form of environmental and ecological problems. Excessive fragmentation, specialisation and diversification ensure the optimality of the sub-systems but at the systemic level produces a range of morbid symptoms [Luhmann, 1982]. The discussion on inter and transdisciplinarity reasserts the compulsions for diversity while emphasising the urgent need for adaptability within varied contexts of application.

Over the last half a century we have witnessed the university lose its primacy as the locus of knowledge production to one in an array of knowledge producing institutions [Gibbons et. al., 1994]. These new institutional forms outside the highly structured regimes of modernity include consultancies, industrial, academic and government research laboratories, think tanks, institutions of national importance, hybrid research institutes across research institutes and industrial laboratories, and finally a new actor joins the network and these include the new social movements [Fuller, 2000]. This institutional differentiation of knowledge producing actors and networks creates a profound need to revise disciplinary maps and curricula but more importantly several scholars have announced the arrival of an altogether new mode of knowledge production. The old academic, discipline based approach to knowledge production is referred to as mode -1, while the new inter or transdisciplinary mode oriented to problem solving located within a variety of organizational arrangements of which the university is perhaps just one nodal hub is referred to as mode-2 [Gibbons et. al., 1994] The table below summarises the two modes.

Table 1: Modes of knowledge production

| **Mode-1** | **Mode-2** |
|---|---|
| Problems set and solved in contexts governed by academic interests of disciplinary communities that are homogeneous | Problem solving governed by the context of application within transdisciplinary communities that are heterogeneous |
| Organizationally hierarchical and form preserving | Organizational hetrarchical and transient |
| Accountability in disciplinary and normative terms | Accountability is social and reflexive |
| Permanent and homogeneous set of practitioners working on problems defined by global and general contexts | Temporary set of practitioners working on problems defined by more specific and local contexts |

The literature on the subject is now rich with debates, but of the range of issues that have become the focus of discussion two issues matter to us here. The first is whether

what we call mode -2 truly inaugurates a generically new form of knowledge production and whether it has come to or will replace mode-1. The jury is out on that one, but it is intuitively obvious that while mode-2 is presently the more visible of the two, mode-1 continues to have a substantial presence and that the two modes do not function to the exclusion of each other and perhaps even complement each other [Pestre, 2000]. The new mode of knowledge production, which it may well be, has been the subject of critique on two principal counts. The first having to do with the evocation of a neo-liberal conception of knowledge ensconced within its rhetorical legitimation in the idea of a knowledge society. The term itself has a very specific connotation with deeply neo-liberal overtones, and the criticism at the institutional and epistemic levels are perhaps not undeserved from the perspective of a more robust and reliable conception of knowledge. We are thus led to ask two nested sets of questions. The first relates to the social structures and networks that will ensure, as did the university, that the knowledge produced is robust and reliable. Secondly, in addition to the university, for there is now no reason to presume that it is or will remain the primary structure for the propagation of a tradition as well as for innovation within and outside of tradition, what other institutional structures will be in place that have a certain cognitive autonomy and safeguard knowledge from political and financial intervention.

Thus from the perspective of a sociology of positionality the intellectual production of individuals occupying positions outside of state or church is characterised by arguments and analysis rather than judgments and policies. Similarly, teachers in colleges and universities belong to a relatively autonomous community and ascribe importance to knowledge that is expressed in the form of general principles or values in themselves [Collins, 1975]. We are now confronted with a situation where the institutional or organizational ground is changing and so it is but natural to ask ourselves about the quality of knowledge now being produced and the knowledge that would be passed onto the next generation. For the sake of argument let us assume that pre-mode-2 or shall we say mode-1 science was characterised by Mertonian norms, then corresponding to each of the Mertonian norms are certain social norms. These are illustrated in Table2.

Table 2: Epistemic and social norms of academic science

| **Epistemic norms** | **Social norms** |
|---|---|
| Empiricism | Communalism |
| Explanatory unification | Universalism |
| Objective reality | Disinterestedness |
| Conjectures and discoveries | Originality |
| Falsfication/Justification | Skepticism |

It is being currently argued for some of the reasons stated above that the social norms of academic science as it metamorphoses into mode-2 also change, and the Mertonian social norms of CUDOS are displaced by a new set of social norms of a system that is referred to as post-academic-post-industrial science. This evidently is the science in mode-2, in which nano-technology, bio-technology and the information sciences create the space for the creation of a knowledge society. The social norms of post-academic science are that it is proprietary in ownership rather than belonging to the global commons, local in its application, authoritarian in its social extension, commissioned in its support and funding mechanisms and centres the role of the expert. As John Ziman has pointed out, we still do not know what the epistemic norms of the new science are like [Ziman, 2000]. It could be said that the paradigms of the sciences of non-linearity and complexity provide some of the frames from which a coherent epistemological frame will possibly emerge. Perhaps at the moment there are many competing or parallel frames, and a synthetic perspective is still to emerge. In this Kuhnian pre-paradigmatic stage there exist several frames anchored and directing the plurality of the sciences.

The preceding discussion has not only argued that we are witnessing an institutional transformation but that this institutional transformation is accompanied by a shift from disciplinary and multidisciplinary knowledge to inter- and transdisciplinary

knowledge. Table 3 below summarises the methods and orientation of these knowledge forms.

Table 3: Methods and objectives of three contemporary knowledge forms

| **Knowledge form** | **Methodology** | **Objectives** |
|---|---|---|
| Multidisciplinary | Juxtaposition of traditional disciplines | Solving a problem or gain an insight into one |
| Interdisciplinary | Extensive integration or borrowing; possible creation of an interdisciplinary field | Solving a problem |
| Transdisciplinary | Transcends disciplinary and interdisciplinary forms; creation of new conceptual frameworks | Influence more than one discipline |

One of purposes of this foregoing introduction has been the need to emphasise the point that in the light of the emergence of these new constellations of knowledge and institutional realities any rationale for developing a curriculum for an integrated science education cannot overlook two concerns, the one historical and the other pedagogical. In the first instance, it is essential to revisit the history of sciences and the history of the formation of disciplines in order to understand the cognitive and social factors that shaped and subsequently resulted in disciplinary fragmentation and specialization. What has happened is that the consensus around this disciplinary and methodological fragmentation has possibly broken down. We need to understand why this is so before we construct new forms of knowledge and classify knowledge afresh, triggering new versions of the culture wars. Secondly, the deeply problematic nature of science education and science curricula in India is not merely a product of simple disciplinary segmentation. The problems reside elsewhere. At least for the last fifty years – since before the Kothari Commission report, attempts have been underway to remedy in different ways what could be regarded as very bad pedagogy.

Obviously enough, the mechanisms of curriculum development at the levels of higher education and primary and secondary education are quite distinct. And these processes have evolved fairly rapidly over the past half century. With the passage of time, and the

development of the national curriculum framework, the process of curriculum development at least at the primary and middle school levels has become more inclusive in terms of the kinds of actors, themes and issues that constitute the very process itself. In terms of disciplinary and cognitive movements that inform the curriculum development process are psychological theories of learning, ideas of multiculturalism and local knowledge(s), and even cultural preconceptions have begun to play an increasingly important role. Curriculum development at the level of higher secondary and higher education is structured by the demand of the market (vocational courses) and on the other hand by the demands of research at the frontiers of knowledge. The challenge today for the university system at the global level is that two fundamental propositions that have structured curriculum development are now questioned. The first is that the curriculum at the graduate level assumes that every student enrolled in a graduate course would be trained to be a researcher irrespective of what the student subsequently does with her or his life [Elkana, 2005]. The assumption is that the repertoire of skills of a researcher is good enough to be applied in a variety of life situations. But this is an assumption that needs demonstration because there exists specialist vocational knowledge just as there is specialist knowledge of a researcher. There is some basis for going along with this assumption based on the empirical work of Rosenberg and others on physics doctoral students. But it could be safely asserted that consensus around this assumption has collapsed. Secondly, the Humboldtian University in the present neo-liberal climate seems to be running out of justificatory arguments especially when governments are urged to support a system of higher education where only 7% of the students enrolled pursue research [Elkana, 2005; Raina and Krishnaprasad, 2006]. Never before has the system of production of knowledge been in such a state of crisis. This implies that there seems to be a pressure building to separate out the system of reproduction from that of production or innovation. But these are larger issues and we return to the pedagogy of science teaching.

Furthermore, once questions of the pedagogy of science education have been resolved the needs of contemporary society necessitate the development of a more interdisciplinary science curriculum. This curriculum would need to traverse several disciplinary boundaries and several cultures of knowledge, not just two or three, but cultures within the sciences themselves. Internally too, science has several disciplinary cultures arranged in hierarchical fashion – not just in terms of the nomothetic and

idiographic sciences, but the great divisions that separate the cultures of the pure sciences and cultures of the engineering sciences and technology. This will be discussed in the section on what STS has to offer. In any case, this is a major hurdle; and we have not even raised the issue of the neglected step child of Indian science, namely agricultural science – or as Shiv Visvanathan once called it the "red light district of Borlaug's boy scouts" [Visvanathan, 1997]. Assuming that this major barrier can be overcome, the next step would be to address the major cultural separation of our times broadly referred to as the two cultures, though in analogy with the internal division of the sciences, there are perhaps at least three cultures, two major ones within the social sciences [Lepenies, 1990]. Finally, and this is the larger philosophical question that we need to ask is whether the frame of integrated or interdisciplinary science education would not lapse into the Carnapian programme of the Unified Sciences but this time in an altogether new guise. In the former case the methods of the natural sciences were centred. In the new scheme we need to ask ourselves from which vantage point would critique be possible if critique and reflexivity is what we wish to privilege in the new knowledge game?

### 1.1 A brief comment on the two culture, three cultures and many cultures

In the present context we take "Integrated Science Education" to refer to the process of including courses from the social sciences and humanities within the curriculum of mainstream science education. The purport of this inclusion we take is to provide a more wholesome education that provides a reflective understanding of the differentiation of the investigated world into disciplines and the contemporary imperatives to transcend these disciplinary boundaries in very special contexts. Interestingly enough we are living almost fifty years after the publication of Snow's essay on the "two cultures" that bemoaned the division of the world into communities of 'literary intellectuals' and 'natural scientists', separated by walls of profound mutual suspicion and incomprehension [Snow, 1959]. The cultural alienation and the near total collapse of communication between the sciences and the humanities (the "two cultures") have generated a very limited perspective of the actual shaping of scientific and literary ideas to the exclusion of each other [Hayles, 1992]. More than producing a generation of students and academics with tunnel vision and capabilities the two cultures debates generates stereotypes where non-scientists believe that scientists were "shallowly optimistic" while on the other hand scientists believed that the literary intellectuals

were "totally lacking in foresight peculiarly unconcerned with their brother men, in a deep sense anti-intellectual, anxious to restrict both art and thought to the existential moment." The context of Snow's understanding of the divide was very "English" and anchored in the progressivism of the 1950s. But without being critical of that era by virtue of sheer hindsight, it must be pointed out that Snow's intention was to overcome that divide through appropriate educational and curricular reform. In his own words his greatest concern was 'how the curricula of schools and universities should be arranged to give people an adequate education in both branches of knowledge'.

The idea of "two cultures" has not gone uncontested. It is not our purpose here to review the critiques of the notion of two cultures. But over the decades there has been a feeling that while the book was an important cultural expression of disciplinary anxieties, some scholars felt that it offered a superficial and conceptually flawed polarization between the worlds of the sciences and the humanities [Becher, 1989]. Like Lepenies, Becher argued that there are numerous and subtle boundaries that characterize the variety of disciplinary cultures. In a systematic study of the 'cultures of academic disciplines' Becher examined the nature of the linkages between academic cultures (the 'tribes') and disciplinary knowledge (their 'territories'). Detailed empirical work lead him to conclude that disciplines could be classified into four main groups that included the pure sciences, the humanities, technology and the applied social sciences. But these divisions are not water tight, for disciplines share common grounds and more often than not adjoining disciplinary groups lay claim to the same pieces of intellectual territory. On the other hand, Lepenies and others distinguish three cultures wherein both the nomothetic and idiographic sciences belong to the same culture, while the idiographic and nomothetic social sciences belong to different cultures: the humanities and the social sciences.

## 2. Different Meanings, Different Programmes: "Science and Society" in Indian Higher Education

The history of science in post-colonial India could mapped into three broad periods: the golden age of scientism spanning the Nehruvian decades that began to wane in the 1970s, the decades of disenchantment with science that extends into the early 1990s, and finally the decades of the rise of neoliberal science in which we are still located [Raina, 2007]. It could be argued that during each of these decades the meanings associated

with the term "science and society" differed as did the focus of science policy making and science education in the country. During the 1950s, that marks the beginning of the golden age of scientism, science was to be mobilised in the task of nation building. As a form of knowledge, as was the case the world over, science was visualised as a cultural universal, and was to be promoted. Typical to the social theory of the times, the success of scientific theories was explained in epistemological terms, while the absence of science was explained by turning to the social dimensions of science. Thus modernisation theory and a number of deficit theories were proposed to explain Indian underdevelopment. As a result "science and society" was a field that had both its diagnostic and prognostic sides in the creation of the new nation. Introducing students to the social context of science would instruct them in the impediments to underdevelopment and an acquaintance with the methods of science would provide analytical tools to overcome underdevelopment. The Kothari Commission Report was suggesting ways of overcoming the limitations of bad pedagogy, but equally with addressing some of the larger issues of science and society[2]. The early attempts to introduce science students to the "extra-scientific" aspects of scientific thinking and scientific practice can be understood in this light. During the golden age of scientism the science and society discourse was not about integrating the sciences and the social sciences but of scientising the social. During the 1950s to the 1970s, it was a common agenda of the socialist and liberal imagination to centre-stage science within culture.

Prof. D.S.Kothari (1905-1993) was professor of physics in Delhi University and made notable contributions to the field of astrophysics and statistical thermodynamics. But his influence upon the community of physics, physics education and the future of science education in the country was related in significant measure to his tenure as the Chairperson of the University Grants Commission between 1961 and 1973. He steered the Kothari Commission that prepared the Kothari Commission Report, which certainly was a landmark report in the history of science education, amongst other things, in postcolonial India [Panchapakesan, 1993]. For Kothari at least a physics education was just not about imparting knowledge of the theories and techniques of physics. On the contrary at the school and undergraduate level he envisioned a role for it in a liberal

[2] Education and National Development: Report of the Education Commission 1964-1966, Government of India Press, Delhi, 1966.

education, insofar as it had the potential of serving as an exemplar of analysis and the so called scientific method itself, apprenticing students with a set of methodological skills to analyze a broad set of problems in a variety of life-situations [Raina and Krishnaprasad, 2006]. Before discussing the programmatic outcomes at the university level of this understanding of science and physics education within a liberal curriculum, I would like to differentiate between two institutional structures wherein the engagement between science and society in curricula was motivated by different sets of concerns and seeded different kinds of programmes. The first part of this section discusses the programmes as developed within the university system in India from the 1960s onwards, and then in the second part we discuss the programme as developed within the Institutes of Technology which were inspired by another idea of providing a humanist garnishing to technocratic pedagogy that defined the IIT system. This attempt is also seen as one in injecting a culture of a liberal education within an environment of specialist polytechniques that were probably being reimagined as micro-universities.

## 2.1 The University System

### 2.1.1 *Delhi University and the Affiliated Colleges*

One of the first universities where courses on the historical or philosophical dimensions of science were introduced was Delhi University. The recommendation that history of science courses be introduced at the undergraduate level especially in B.Sc. courses was a product of thinking within that box. As pointed out by Prof. H.S. Virk: "The first time history of science was introduced in India was in the B.Sc. (hons) course in Delhi University – the course was possibly introduced in 1965 or the late 1960s; the course was optional and followed out of the recommendations of the Kothari Commission". The course was introduced as a B.Sc. level qualifying course and was taught at St. Stephen's College by a legendary physics teacher called Dr. Tara Chand[3]. A book authored by somebody called Hariharan was used as a reference book by all students enrolled for the course. The students were supremely indifferent to the course and within a decade or so the course was more or less dropped. Consequently, while the

[3] It appears that Prof. Maheshwari taught a course on the history of biology In the late 1950s in one of the Delhi University Colleges.

course itself was a disaster, the Delhi University physics department kept a kind of reflexive engagement with the subject going in the hope that the history of physics would arouse an interest in students of some deeper issues about physics and society and physics education. Despite the fact that the course itself was discontinued in the mid 1980s, the reflexive engagement found expression in debates on quantum mechanics and nature of science amongst doctoral students and faculty of the University in the early 1970s. Some of the doctoral students with the help of the faculty went on to found the Hoshangabad Science Teaching Programme (HSTP). As pointed out by the educationist Krishna Kumar, the HSTP was the first attempt in India to set up a school science teaching programme on an altogether different epistemological foundation. Much later those associated with this experiment in association with other physics teacher's inaugurated the Centre for Science Education in Delhi University. The idea for developing such a Centre was mooted when Moonis Raza was the Vice Chancellor, and the idea was possibly thrown up by Yash Pal. P.K. Srivastava was the first director, and amongst the many involved were Vijay Verma and S.C.Bhargava – physicists from Delhi University. The moving spirits just mentioned played a significant role once the Centre was established. The first meeting of the Centre was held in 1985, but as a Centre it was formally recognized in 1986-87 and moved to its first office on 10 Cavalry Lane. After Yash Pal took over as Chairperson UGC the centre received support on larger projects and P.K. Srivastava was formally appointed to the Centre in 1997.

In an interview with Prof. Anita Rampal of the Centre for Science Education and who has been closely involved in the development of the National Curriculum Framework, the interests of the students on the nature of science and the social dimensions of science were inspired by their teachers in the physics department such as Kamal Dutta, P.K.Srivastava and many others. Some of the finest minds in the science teaching movement and the people's science movement appeared on the scene during this period – Amitabh Mukherjee, Vinod Raina, Anita Rampal, Sashi Saxena and Ratna Saxena.

Getting back to the course that was dropped, attempts were undertaken in the 1990s to reformulate the course and have it approved for the undergraduate science curriculum. The course was last restructured in 1992, and there was no place for history of science in the revised course. In the early 1990s a seminar was organised to develop a new

syllabus for the history of science again to be introduced at the Bachelor's level. The seminar also raised questions about educational opportunities available in science education itself. Clearly two things were happening. In the first instance, there were faculty members within the community of scientists in DU who continued to see the importance of a history of science course in a science degree programme. Secondly, by the early 1990s a new academic or disciplinary network was making its presence felt in India and that was the community of educators trained to teach and research science education. Their interests were now being articulated in the academic community. This was reflected in a Workshop on "Science Education and Career Opportunities" organized in October, 1996 by the Centre for Science Education and Communication, University of Delhi.

One of the outcomes of the seminar was the establishment of a Working Group to replace Hariharan's book on the history of science and a new course was proposed to the university this time called "Science and Society". The course was to have four components: [1] The History of Scientific Ideas – which was already present in the earlier course. The other components were possibly new and reflected the growing concerns of the times. These included: [2] Science as a knowledge system, [3] The Social Setting of Science, [4] Growth of Science in India. One of the intentions of the course was to unsettle received notions of science and society prevalent amongst students of science. At a seminar again organized at Delhi University on science and society in 1994/95, in which there were few participants, the relationship between science and the other disciplines was also discussed.

In the months that followed, regular meetings were organized where a number of concerned academics from a variety of research institutions and universities in the city attended. P.K. Srivastava was then director of the Centre for Science Education. The efforts were to draft teaching guidelines and a syllabus. The Committee was given a green signal to finalize a new draft of the course and it was felt that non-lecture instructional modes should also be made an integral element of the course – this included discussion, case studies, group projects - for example examining the tons of data on science and scientific research in India etc. The principals of the colleges affiliated to Delhi University were invited to meetings to put the final touches to the course. Typically it was thought, that an essay by Thomas Kuhn be included in the essential readings of first year degree students, Paul Feyerabend's writings were

considered a little too dense and perhaps subversive of science as well. Anderson's book on Saha and Bhabha was considered just about the right level to resonate with the societal awareness of students [Anderson, 1975]. Furthermore, we feel that the positive feelings about the book had to do with the fact that it served both as heroic biography and sociological narrative about the community of physicists.

However, the Committee was not given the go ahead to prepare a reader for the course, and the University procrastinated over the proposal for a long time. During the tenure of Deepak Nayyar as Vice Chancellor of Delhi University an "Empowered Committee" was established to review the course and come up with suggestions. The Committee was comprised of some eminent scientists from the Indian Institute of Science, Bangalore – but as happens with the committees comprising eminent scientists, the schedules never converged and no document was produced. The Centre for Science Education was in fact rarely consulted once the Empowered Committee was appointed. In 2004 another Empowered Committee was created to look into the matter, but this time around, the Committee was comprised of local members and the Committee came up a with a report that was critical of the course. The overall reaction was very negative. It was decided that the B.Sc. (Hons) course would not be touched. The B.Sc. (General) course became the B.Sc. Programme. "Science and Society" was dropped but the other parts of the science course as suggested by Amitabh Mukherjee and others were adopted.

During the course of our interviews with Amitabh Mukherjee a number of interesting themes were touched upon. For example we asked about the non-standard arguments proposed by enlightened scientists to justify a course on science and society, or a novel curriculum that included "science and society". The arguments Amitabh proposed make perfect sense within a conception of the liberal university of culture and democratic citizenship. He informed us that the two cultures divide had split the university in two. It was increasingly visible as one walked from the department of physics towards the Arts Faculty. The first thing observed on approaching the Arts Faculty was that the students were far more articulate and informed about social issues. The world of the Master's level physics students was particularly insular almost by design.

Ideally speaking it has been felt that the first year of the Bachelor's level curriculum is the time for unlearning a great deal of that which has been passed on through the schooling system. The science and society course he felt should be offered not just to science students at the university but to all the students at the appropriate level. There were several issues that needed to be sorted that created the need for rethinking science. One of the limitations of the course on the scientific method was that it engaged only with the methods of the natural sciences. Secondly, it sort of played into the idea that was inscribed through the pedagogy of Indian schools namely that science was a product. There was an overall shift in student's perception of science education between the 1960s and 1990s. In the 1960s, science was different from other kinds of academic pursuit but it was not boring. This notion was revised in the 1990s when science came to be seen as boring and definitely dependent upon the authority of the teachers. In this transition there was a loss of any engagement with what "knowing" and "understanding" involve. Amitabh and his colleagues have bravely sought to remedy such misperceptions about science and science education.

Despite the fact that the courses on science and society and philosophy of science have been turned down, the Centre prepared another document where they again attempt to engage not only with a new science curricula but equally to push forward their reflective and social concerns about science and society that need to find an echo in a liberal undergraduate education[4]. Within the Centre a short term course has been proposed on science communication. However, it was not yet clear whether such a course be included in the curriculum on the philosophy of science or science and society. It is not a case of either or but of how much can be squeezed into an undergraduate curriculum.

Independent of these efforts, but surely informed by them, the department of Germanic and Romance languages in Delhi University has for sometime been running a course on the history of scientific ideas. The department does not employ faculty to teach the course, but invites faculty from affiliated colleges and university departments to do so. Till recently the course was initially taught by a philosopher from St. Stephen's College

[4] Restructuring Undergraduate Science Curriculum: A Draft Proposal for the Next Millenium, Centre for Science Education and Communication, University of Delhi, 1999.

and later by a philosopher of science from the University. The presupposition of this curricular innovation is that students of languages need an appreciation of the history of scientific ideas.

2.1.2 *Department of Physics, Guru Nanak Dev University, Amritsar*

It is not at all surprising that enlightened physicists associated with the Department of Physics of Delhi University, pushed so hard to develop and initiate major curricular changes in order to promote a different vision of science and society, and of the relationship of science to the other disciplines. While thus far it has been a failed project like many others in the country, it nevertheless produced fortuitous positive outcomes as well. The interesting part is how a programme on the history and philosophy of physics was initiated at Guru Nanak Dev University, Amritsar and ran for a number of years before, like in Delhi, in and around the same time, it was discontinued.

The moving soul behind the programme was H.S.Virk, a product of Aligarh Muslim University, where he did his Master's in physics. He went to Paris much later where he submitted a doctoral thesis that challenged the discovery of an elementary particle. He claims that this episode taught him that even in the sciences there were perspectival differences in the study of phenomenon. Further, this led him to conclude that there are several ways of explaining the same phenomenon and there is nothing final about the claims of the sciences.

In 1975, the historian Satish Chandra took over as Chairman of the UGC and he too promoted the idea of starting a course in the history of science. A UGC circular was sent to all universities, and one such circular reached the department of physics at Patiala University where Virk was then located. A few months later a National Workshop on the History of Science was organized and about 20 participants attended, as did Virk and a physicist colleague from Patiala, Satish Chandra, D.S. Kothari and the director of IIT Delhi Prof Sodha as well as the directors of the other IITs. According to Virk, despite the good intentions, the time was not ripe for the initiation of the course. But on examining the list of invitees it appears that no practicing historians or philosophers of science were present at the meeting. In any case, the conference concluded with a resolution proposing the creation of the Indian Association for the History and Philosophy of Science and Virk was made a member of the panel, possibly the youngest

member. The other members included the biologist from Delhi University Prof. Mohan Ram: Abdur Rahman who had been campaigning independently for the creation of the course since the 1950s was either not invited or did not attend the meeting. Nevertheless, a course on the history of science was approved by the UGC and it was decided that initially the course would be offered at a few institutions. But the Delhi University course was already in doldrums, the course at Indian Institute of Technology, Delhi did not take off at the time, and the Birla Institute of Technology and Science, Pilani was the third place and we shall come to that part of the story soon. – but the course was in doldrums; BITS - Pilani, and IIT-Delhi didn't take off.

Virk's own interests lay in researching the history of sciences in India as well, and he received funding for the same. However, in 1980 he moved to Guru Nanak Dev University, Amritsar and took over as Chairperson of the Department of Physics. In 1987 a course on the history and philosophy of science was introduced at the M.Phil. level. According to Virk, the students did not really appreciate the course. One of the reasons Virk started off in the philosophy of physics was there was enough literature on the subject; and despite the aversion of the students to a philosophical treatment he claims they appreciated the exposure to physics in terms of its historical evolution. Similarly, when teaching the history of science he used Bernal's Science in History; a book sometimes used by some course instructors at the School of Germanic and Romance languages, Delhi University. What Virk didn't know was while the book was insightful on the relationship between technology and science as a history of science it was already outdated by the time it was published [Ravetz, 1992]. Anyhow, the course was dropped in 1995, by the time Virk left the department. In fact, the course died with the termination of the M.Phil programme at the university. Three factors appeared to have contributed to the poor reception of the course. There was no specialised teaching faculty to teach the course. The paucity of teaching material at the student level was the second factor. In fact, very often the University had to invite instructors from external institutions to spend two weeks at the university and teach the course. While there were many monographs available on the subject, there were few textbooks available in a university culture where textbooks are the norm. And finally, there was no question bank, standard examples and questions which constitute the culture of Indian university examinations. Finally, in a profound moment of self-criticism Virk confessed

that while he was inspired by history and philosophy of science he himself was not an inspiring teacher.

There were a few other aborted attempts, another case being the B.Sc. (Hons) course in Chandigarh. The course did not take off again. Repeated attempts failed because the entire enterprise was trapped within a highly technocratic pedagogy and the failure to see that a number of logistic inputs were absolutely essential in order to develop a course in a field that fell across two major cultures that divided the academic worlds. In 1987 or thereabouts Virk organized a National Conference on the History and Philosophy of science at GNDU. Though it was called a national conference only 15 delegates were present, and one of the invitees was the then UGC Chairman, Yashpal. Yashpal was totally disappointed by the presentations. And this may have influenced his decision to keep any further support for the subject on hold. Interestingly, enough there were few professional historians of science invited to this meeting. This was round about the time a whole new generation of scholars was presenting their work in international journals and conferences. Had they been invited decision makers at UGC may possibly have thought differently. Even though Virk was not a real professional in the field, the commissions did not possibly possess a model for institutionalising a non-standard discipline.

### 2.1.3 *Indira Gandhi Open University, New Delhi*

In the late 1980s Indira Gandhi Open University, New Delhi inaugurated a bachelor's programme in the sciences for their correspondence courses. The course structure was seriously reflected upon and some of the people involved in course development had been in the field of education for quite sometime, had thought very carefully about what a good liberal education must comprise, and were themselves deeply conscious of how a good bachelors science course must be structured. It would not be irrelevant to consider them as part of the reflection that had been initiated within Kothari's scheme. Thus when the curriculum was developed one of the courses offered as a compulsory course was 'The Foundation Course in Science and Technology'. The course was compulsory for all the undergraduates – this was guided by the idea that undergraduate education should be as broad based as possible and provide a wide perspective on science and society to all students. The foundation course is composed of several modules each of which is called a brick. Each of these bricks was drafted by a

team of scientists and social scientists from India's premier research institutes and universities.

The brick on the history of science was not conceived as a chronological description of the events of scientific discovery; but as an account of the process of interaction of science and society. Some of the chapters dealt with

- Science in the Ancient world from hunter/gatherer societies to the Indus Valley Civilization.
- The Iron Age: Emergence of urban societies, Iron Age in Greece.
- The Golden Age of Science in India: The Gupta Period – growth of mathematics, Astronomy etc.

While some of these issues were constantly being revised in the light of new research, the broad objective of this course was to understand the development of science and technology in Indian society, and to illustrate how the methods of science were applied to solving problems in real life. In any case one of the key objectives of the curriculum was to cultivate what Kothari himself had argued was a scientific outlook towards life that involved objective thinking and a rational approach.

The second brick dealt with the 'Emergence of Modern Science' drawing a narrative of historical evolution from science in the medieval world, to the scientific renaissance, the Industrial Revolution and after, culminating for historical and topical reasons with science in colonial and modern India. Finally, the brick closes with the method of science and the nature of scientific knowledge: scientific approach to problem solving. From a historical perspective students are gradually introduced to the elements of the scientific method. Having discussed the evolution of science as method and a way of cognizing the world the course moves outwards surveying in a third brick the `Universe and Life – The Beginning' with an emphasis on the universe as a system to the origins and evolution of life and the human species. From here onwards the subsequent modules deal with issues of environment and resources that elaborate upon the dependence of all forms life on their environment, including a discussion of the ecological features of the oceans, atmosphere and forests and the kind of life they sustain. There are four other modules on 'Agriculture, Nutrition and Health',

'Information, Knowledge and Insight', 'Science, Technology and Development', closing with 'New Perspectives' that seek to explain the linkages between science and society in order to provide citizens with tools for responsible social action so that the risks that are the outcome of scientific and technological development may be minimized and the gains enhance the quality of life. However, the feedback on this course reveals that it is considered quite "heavy" by the students. And the IGNOU is now in the process of redoing the course material.

2.1.4 *Other University Programmes*

One of the first post-graduate programmes in the social studies of science was established at the Jawaharlal Nehru University within the School of Social Sciences and was located at the Centre for Studies in Science Policy [Banerjee, 1996, p. 38-39]. The programme is an M.Phil./Ph.D programme and the teaching programme covers much of the material that is swept under the rubric of the social studies of science. At JNU, the philosophy of science appears in some form or the other in all the specializations at the Master's level offered in the School of Social Sciences, with the exception of two Centres – the Centre for Historical Studies and the Centre for Economics and Social Policy. Clearly at these two extremes of the spectrum of the social sciences, we see a playing out of the idiographic and nomothetic science distinction. The schools of the physical or life or environmental sciences maintain a distance from such methodological reflections. Similarly, at Central University of Hyderabad, the Department of Sociology and the Department of Philosophy, have been attempting to get science students to take courses on the sociology, history and/or philosophy of science over the last couple of years but have encountered only resistance. However, the departments run a regular M.Phil and Ph.D. programme where students can pursue investigations into the history, philosophy and sociology of sciences. Given the social studies of science current preoccupation with technovation studies, the school now has a Centre for Knowledge, Creativity and Innovation.

The University has introduced an integrated five year master's programme in the sciences. In both these schools it was suggested that for the first three years all students would pursue the same courses and then in the 4$^{th}$ and 5$^{th}$ years the students would specialize; none of the science departments accepted this proposal; it was even suggested that 15% of the courses in the science departments would be non-science

courses – even this proposal was not accepted since it was felt that the sciences desired vertical and not horizontal integration. The mathematicians even suggested that their students did not need any exposure to chemistry or biology.

Furthermore, in the 1990s both Pondicherry University and Madurai Kamaraj University ran a post-graduate course on Science and Technology Communication supported by the National Council for Science and Technology Communication, New Delhi. One of the intents of the courses was to produce a cadre of professional science communicators. These courses in addition to much of what goes by the name of communication science had a substantial component on the history and philosophy of sciences and the "social studies of science". The courses were run by those with a basic degree in mass communication and the portion on the history and philosophy of science was taught by guest lecturers. The question papers were prepared and the answer scripts were evaluated by these guest lecturers. These courses suffered from many difficulties. For one, the students who had enrolled for the courses had no idea why they were doing these courses – it was just one amongst the large basket of post-graduate courses that universities offered that gave students an opportunity to extend student life until a job came along[5]. The university saw it as an opportunity to run a course for which no expenses were incurred by the two universities – the NCSTC was sponsoring the course. However, neither the universities nor the NCSTC benefitted. There was no spill over from these new disciplines into the other courses offered at the university, and the NCSTC found that the necessary cadre was not appearing. After about four years both courses were discontinued. As for the others, they either went on to enrol in other courses offered by the university or found an appropriate vocational opening that was more satisfying.

[5] One of the authors of this report (DR) used to be invited to teach the course on the history and philosophy of science. He was once horrified when he innocently asked a student why the latter had opted for the course and was told that the student was hoping to get a job in the department of telecommunications. DR knew some of the students who enrolled for these courses, and observes that only one of the students - T.V.Venkateswaran – ended up in a job closely informed by anything that was taught in the course.

## 2.2 The Elite Institutes of Technology

Outside the university system, the attempts to get courses on "science and society" rolling revealed a greater degree of success than in the university system, and we shall try to uncover some of the reasons that possibly explain their relative success. But there are several important organizational features of the "institutes of technology" that enabled this trajectory – for one these institutes are not universities. They are specialized technical micro-universities primarily oriented to teaching and research in the engineering disciplines and supported by the science departments. With the passage of time departments of humanities and social sciences were also created and this section discuses their place within these centres of technological education.

As suggested in the previous section one of the first of these technical institutes to propose and run a course on the social studies of science was the Birla Institute of Technology and Science, Pilani. By 1976 they were running a course called M.Sc. (Technology) which was different from an engineering degree. Gradually the institute offered dual degree courses and the M.Sc. (Technology) course by the 1980s was being offered as a course in science and technology studies. A core group of scientists from CSIR head quarters taught the course, and A. Rahman, the historian of science and science policy expert, and founder director of NISTADS, was involved in establishing the course. The curriculum included courses on: science policy, science communication, research and development – these were the main courses. The plans to develop the course further failed because negotiations with the CSIR broke down at some point and there were not enough teachers to teach the course. This condition was more or less shared with the efforts undertaken at the university. However, there was flexibility in choosing the courses that were on offer. The pursuit of the course involved a great deal of self-study with little faculty guidance or supervision. In their practical training programmes the students who had taken these courses spent about six months at NISTADS working with scientists pursuing researches on different aspects of what used to be called science of science studies. However, by the mid 1990s the course was discontinued.

### *2.2.1 Indian Institute of Technology, Kanpur*

The department of humanities and social sciences in most of the IITs were established at the time of the founding of the IITs. The IITs had adapted a model of technical education wherein the Department of Humanities and Social Sciences offered courses at the undergraduate level for students of the engineering and the sciences. Courses on philosophy were run by this department but till about 1982 there were no specific courses either on the history and/or philosophy of science. Prof. I.S. Minhas who retired a couple of years ago as Professor of Physics from Punjab University, Chandigarh, was a student at IIT-K from 1964 to 1975. As a student he acquired an interest in the philosophical foundations of physics, in particular on operationalism and special relativity – a subject on which he was to write a number of papers[6]. The philosopher Prof. Mohini Mullick taught philosophy of science courses as a philosopher at the post-graduate level. However, Prof. P.R.K. Rao reminisces that in the 1970s and 1980s Humanities and Social Sciences was seen as a necessary evil. In fact, the joke doing the rounds at the time, which reflected the inner technocratic anxiety, was that the department could potentially transform the Indian Institute of Technology into an Institute of Indian Technology.

In 1982 there was a directive from the Ministry of Education, Government of India that students enrolled for B.Tech courses at the IITs should be exposed to the history of India's contribution to the world of scientific ideas, with special reference to temple architecture and ship building. Professor A.P. Shukla of the Department of Physics and Prof. P.R.K. Rao of the Department of Electrical Engineering, both legendary teachers in the annals of IIT-Kanpur, responded by floating a course on the history of scientific ideas, where Rao dealt with issues of philosophy of science and Shukla dealt with the history of science that he approached from a broadly left wing historiography of the history of science. Shukla was concerned with issues of conscientization and possibly came in from the social relations of science tradition that saw the role of science in

[6] Back in Chandigarh, Minhas taught quantum mechanics but the philosophical debates were discussed just in passing and never in detail. He feels that the courses taught at GNDU and the little discussion he may have initiated in Chandigarh had no impact on the student community – possibly because courses in any case were never structured to have any impact but only to be passed.

transforming and re-engineering Indian society. He had previously worked at BARC for six years before going off to USA off to do his Ph.D in nuclear physics and came back after completing his degree. Prof. Shukla pointed out that the humanities and social science department was part of the structure of the IITs from the very beginning. But like the departments of the sciences they were initially seen as service departments rather than having an independent identity. With the passage of time they acquired a sense of their own identity.

However, when Rao and Shukla planned the course with their colleagues the feeling was that a self-reflexive attitude to the activities of scientists must be inculcated amongst the undergraduate students. In the under graduate programme students were expected to take three courses outside the department in addition to their stream electives. With Prof. A.K. Biswas courses on the history of science and sociology of science were offered. Other engineering faculty members were also asked to deliver 4-5 lectures to their students on the history of their disciplines. But the response from the engineering faculty was not very positive.

Finally the course "History of Scientific Ideas"was taught by Shukla (physics), Rao (electrical engineering), Jerath (humanities and social sciences) and Gandhi (chemical engineering). The scaffolding for the course was provided by the work of Djiksterhuis and Koyré, and included some meta-theory of science and original readings from Heisenberg and others. The course was taught from 1982 for about twelve years and is no longer taught. Rao himself once in a way lectured on the philosophy of science. Normally about 25 students registered for the course with as many students auditing. This was because the students were informed that the grades would be as hard to come by as in the quantum mechanics course. The course appeared to have left a deeper impact on students who audited the courses than those who registered for the same. Evidently, those who audited the course had the option not attend the class at all, and those who attended wished to get the most out of it. As for the impact on the rest, we have an insight into how successfully the technocratic imagination has embedded itself within the community of students at the IITs. But the students' reviews of the courses proved very encouraging. A rather important observation was made by Rao, when he pointed out that the true success of these courses resided in the fact that the science and engineering teachers themselves taught the courses – Rao, Shukla at IIT-K, and Agashe

and IIT-B were legendary teachers but all practicing scientists. They had all bothered to sit through social science courses offered by their colleagues in HSS and then reverse engineered the course for their students. This sort of pressurised the students to treat the courses in the same way as they treated other elective courses.

But more importantly, IIT-K played an important role in producing students who would later enter into teaching positions at the other IITs and universities where the social studies of science were undertaken. Prof. Vinod Jerath after completing his Ph.D came to IIT-K from Delhi University in 1979 and he was there till 1984; Prof. Haribabu obtained his doctorate in sociology from IIT-Mumbai and joined IIT-K as faculty in 1985. Both of them taught sociology of science, and introduced Mertonian sociology of science to the students. Jerath and Haribabu introduced a course on science and society as well. Mertonian sociology of science was the prerequisite for the introduction of the post-Kuhnian critique of Mertonian sociology of science. Ironically enough, the positive reception of Mertonian ideas had to do with the Merton's functionalist sociology of science that enabled the analysis of the dysfunction of science. Both Jerath and Haribabu are now at the Central University Hyderabad. One of Jerath's doctoral students went on teach sociology of science in IIT- Madras. Prajit Basu once a student at IIT-K pointed out that one of the good things at IIT-K despite the specialization was that it allowed certain kinds of interdisciplinary conversations. This was achieved by recognizing that the students who came into IIT were very capable, and the faculty did not curtail a student's efforts to learn new things. These students who opted for courses outside the department were seen to fall within the four standard deviations on the negative side and the system could live with these deviations. The system was not threatened by permitting these peripheral systems to remain afloat.

S.G. Kulkarni who went on to inaugurate the philosophy of science course at Central University Hyderabad and V. Sanil currently at IIT-Delhi, did their Ph.D in the philosophy of science from IIT-K. Kulkarni did his doctorate with R.S.Mishra. One of the reasons he went to IIT-K from Mysore University was the feeling that Mysore University was the bastion of traditional philosophy, both Eastern and Western. And the IITs appeared to offer the opportunity of introducing students to contemporary issues in philosophy. So when he arrived in Kanpur, the philosophy of science was still not taught at IIT as a post-graduate course. However, Mohini Mullick was teaching

philosophy of science to undergraduate students, albeit the course was called "Scientific Method". Nevertheless, the interest of Kulkarni was itself aroused by two physicists in Mysore University who were interested in Whitehead's ideas. And IIT-K's environment offered him the opportunity to explore the field of contemporary philosophy of science.

When quizzed about the idea of an integrated science education Shukla, inveterate optimist that he is, found it appealing inasmuch as it would enable students to see through the deep social problems that afflicted Indian society, and how complicated technological solutions could create more damage than harm. After retirement he is teaching a course at the IISER, Mohali that attempts to highlight the distinction between STL (science, technology and labour) and ESTM (e-science technology and medicine) where the "e" connotes many things from expertise to expropriation[7].

Similarly, Rao after retirement from IIT-K continues to be associated with the science and society programme at IISER, Mohali. He lives in Hyderabad and now teaches at the Indian Institute of Information Technology, Hyderabad. There too he offers a course he calls "Images of Science", since he feels that "philosophy of science" will scare away students of information technology. One of the authors of this report probed him about the potential of an integrated science programme. At the more general level Rao is of the opinion that canned or packaged courses will not help in this country, for every faculty member will have to contextually decide which kind of course content will go down best with the students. He also cautioned against the likely circumstance that a methodologically reflexive scientist may cease to be creative enough for this reflexivity may rob him or her of her or his gung-ho attitude. The rationale of the course for the science and engineering student must then be to sensitise the student qua human being and not qua scientist. Furthermore, Rao in a more critical vein felt that the humanities have never challenged the sciences nor have the departments of HSS posed any questions about the kinds of knowledge production activities that go on within their own institutes. Which is why a course anchored in the social epistemology of science rather than philosophy of science could make more sense for the students. In any case it

[7] His commitment to the field has been such that while at the IIT-K he even translated Kuhn's The Structure of Scienific Revolutions into Hindi.

is important to note that a course such as this will only serve a limited objective as does a liberal education.

### 2.2.2 *Indian Institute of Technology, Delhi*

As in the previous sections this narrative is constructed through conversations of faculty members who have been actively involved in the construction of the curriculum on "science and society" in India. In the 1980s a course on science technology and society was taught at IIT-D. But it was only by the late 1980s when a new bunch of faculty members joined the department that a new agenda was prepared for the department of humanities and social sciences. The first was to change the perception of the HSS as a service department for the institute, which meant developing its own programmes in teaching and research driven by the internal cognitive momentum of the discipline. The other had to do with ensuring that students of engineering be exposed to the history of technology with an exposure to the history of their own disciplines. This happened during the directorship of Nigam. One of the faculty members was Prajit K.Basu who had a Ph.D in chemistry from Indian Institute of Science, Bangalore and then another in the history of science from University of Iowa. As far as the studies of science and society were concerned Prajit introduced courses on philosophy of science and sociology of science at the undergraduate level and philosophy of social sciences and sociology of science at the post-graduate level.

Reflecting upon the courses that he introduced and taught for more than a decade before he moved to Central University of Hyderabad, Prajit felt that he organized the courses in order to get students to think about problems qualitatively and think through them in a structured way. This was done in courses such as one on the history of logic, which was taught differently from the way the course is taught in a computer science department. The intent was to introduce students to examine arguments and engage with these arguments with an analytic rigour. Typically he led them to examine the ambiguity of certain kinds of statements: "it is our culture" (particularly during the days of the ascent of Hindutva). Or how do we decide what is ours? In other words Prajit's courses were inclined towards endowing the students with some metatheoretical instruments that enabled them to question their forms of reasoning and argumentation. History was seen as a prerequisite for introducing historiographical

ideas: what is data or what is theory. In other words the students were introduced into problematizing what was strange for them from their day to day discourses.

The STS course was introduced to instil the idea that science was a social practice. The students were sent out on practical projects in industry to study how technologies were conceived in a social context, in order to explore how different conceptions of technology came to be socially embodied. It was this embodiment that created the sense that technology was appliance, or merely some kind of specialist knowledge. At the post-graduate level the philosophy of science course was taught as a course on the philosophy of science namely from the perspective of questions considered epistemologically important for the practice of science.

From the point of view of the students of science and engineering it was important to engage with the feeling that science has successfully isolated itself from peripheral cultures by developing a language that is accessible to the initiated. The success of science was thus contingent upon the elaboration of this language. The condition for the success of science provided STS the opportunity to bite into science with the conceptual instruments of hegemony, exclusivism etc. This insulation of science from the surrounding culture in its moment of triumph deters other conversations from taking place. Prajit K. Basu trained as a chemist points out that the language of synthetic organic chemistry can be quite pictorial and differs from the language of theoretical chemistry, whose language is highly mathematical. Consequently, at the undergraduate level a number of interdisciplinary conversations are curtailed since these conversations require openness to the specialist languages of other disciplines. The absence of these conversations curtails an ontological or epistemological understanding of what is at stake in the domain of science.

Prof. Rukmini Bhaya Nair, is a linguist and well known poetess who also teaches at the department of humanities and social sciences at IIT-Delhi. She has been teaching a course on technology and culture for many years to undergraduate students in addition to the post-graduate courses that she teaches. The students were introduced to the basic readings on the subject from Heidegger, Aristotle and Gandhi. But she has often seen some of her courses as opportunities to explore how a technologist understands the world. Some of these reflections appeared in a book published many years ago called

Technobrat [Bhaya Nair, 1997]. Rukmini feels that the book was considered unreadable within the IIT system. The reaction was hostile, while the narrative itself was a non-linear one. Social scientists saw this as an experimental construction and gave the book a different reception.

Typically, Rukmini has been trying to study how technologists produce literary texts. For the IIT student the cell phone is the closest technological object, and in the course Rukmini has experimented with the production of an SMS novel. The underlying hypothesis was that almost every technological revolution produces a new literary genre. Rukmini employed contemporary themes for the study. One of the features of modernity was the compression of space-time. The cell phone is emblematic of this compression, and the modern novel is compressed into the SMS novel.

In the imagination of the IIT-technobrat the sciences and social sciences are quite distinctive entities. The sciences are about "we", a "collective" enterprise; while the arts are about I, and originality. Rukmini sees the IIT student as sacrificial victims at the alter of modernity. According to her any conception of liberal education has a notion of in-built relativism or of there being other alternatives. Further it also involves pursuits that are not necessarily part of a vocational apprenticeship. In other words, there is a tendency among the students within the IIT-D system to see the social science courses as "halkah courses" (light courses), serving thereby as surrogate decompression therapy. Discipline and punish in the IIT context according to Rukmini manifests itself as conform and compress. Now the moment of decompression is a promising one in that it provides an opportunity for self-questioning and self-doubt. This ability comes from a familiarity with language. Actually one finds that scepticism is no longer an epistemological virtue even in the humanities. Rather there exists a strong tendency to go native, due to lack of irreverence. This lack of irreverence limits the space of decompression by underlining the significance of problem and precision.

Prof. V. Sanil is also a faculty member at the department of humanities and social sciences at IIT-D, where he joined after completing his Ph.D from IITK. As a student he audited the undergraduate course taught by Shukla and Rao. Sanil currently teaches a course on art and technology, another one on philosophy and film, and a third one on

moral literacy and moral choice. Sanil too attempts through his courses to engage with the world of engineers. The course he runs on art and technology seeks to contribute to the imaginative world of engineers. As Prajit had pointed out, one of the tasks was to develop a structured way of thinking even within discourses considered non-scientific and Sanil would like the students to experiment with film as technology. The focus of the course is not so much cinema as a work of art. The orientation is not on aesthetics or cultural studies, but seeks to explain what cinema can explore. About 30 students register for the course every semester because that is all the hall can accommodate; and they proceed to investigate the culture of film-making. Some of these students have gone on to become film makers and novelists. In any case, the majority of the students end up in financial consultancy and not engineering jobs.

As happens to be the case at several of the IITs the course structure is not the same every year – this is the advantage of the IITs as opposed to the University system (JNU being the exception). In fact, depending upon the overall social context a different theme could be taken up every year. For example, one year Sanil taught "perspective and measurement" in the arts.

We spoke to a number of faculty members from IIT-D about what they believed was expected of a good science or engineering education. Is the objective merely to produce good scientists and engineers or is it to produce something else" All of them felt that this issue needs to be thoroughly debated within the context of IISERs and the large number of universities that are likely to be established in the near future. Do we wish these students to be linked to wider culture or do we wish to instil in them the idea that knowledge gathering is the only worthwhile aspect of human life. If the latter be the case, given the rate of advancement of scientific knowledge, these students will soon be rendered dysfunctional if not structurally unemployed. If the idea of science itself is so limited, then the idea of what constitutes research is even narrower which then begs the question whether this would constitute a fruitful model for scientific research to be emulated by students?

One way to address some of these issues, Prajit feels is to develop courses around the STS framework, which would also provide an easy way to pedagogically approach the question of science within culture. For example, by taking Galileo as exemplar, a number of themes from the domain of science and society could be developed, such as

that of science and religion, science and techniques, science and politics, science and language.

Rukmini on the other hand feels that within the IITs the examination system is an instrument for disciplining the IIT-ian even though there exist means of subverting it while keeping to the golden mean. This process of disciplining is basic both to the sciences and social sciences. Within the IIT system this plays itself out by limiting the space for bildung, or for the student to cultivate her or his own academic passions within the IIT system. In order to allow some space for bildung requires a radical structural reorganization of the curriculum and a rethink of the goals of the IIT. Rather than passion, preoccupation and commitment what is encountered is irritability, boredom, anxiety – the lesser emotions, or the post-modern emotions that suffuse the IIT system. This is a point of view that is not necessarily shared by everyone.

Sanil drew upon his teaching experience to suggest that some of the students who enrolled for his courses were more reflective (not necessarily more reflexive) while a few isolated students were not afraid or cautious about being imaginative. But the special nature of the IITs needs to be reckoned with since the IITs and the IISERs are not universities in the sense of the University Culture and democratic citizenship [Readings, 1996]. In the previous generation a great deal of learning and radicalization took place at the IITs because there still existed a strong culture of reading and the students were politicised. In a neo-liberal culture this is unlikely to be the case because neither is a desired objective.

Currently, the IIT structure permits UG students to undertake minor projects in the humanities. About 120 students registered because these courses were considered "halka courses". More than the STS kinds of courses students beeline for economics and econometrics courses revealing a preference for finance oriented courses that could come in good stead when they apply for the IIM and other management courses. The course load is about 15 credits in the humanities out of a total load of 160. However, Sanil feels that just now it is the PG programme that needs a bolster. In any case the two cultures divide does play itself out within the IITs – the humanities and the social sciences department does not recruit faculty with engineering backgrounds. The turf war plays itself out in different ways.

However, his long term fears are that the new ICT courses that come under the "Washington Accord" are structured in a manner that the curriculum will become more teacher-independent. This will result in a major rethinking of the engineering curriculum. The IITs have joined the programme and this has created countervailing pressures. Since the pedagogic objective of such a programme is to connect every lecture to an object and not a global disciplinary solution it appears as if even within teaching contexts we are witnessing the onset of mode-2.

### *2.2.3 Homi Bhabha Centre for Science Education*

The Homi Bhabha Centre for Science Education, Mumbai is a National Centre of the Tata Institute of Fundamental Research that runs a graduate teaching and research programme on science education. The history and philosophy of science was one of the disciplines that constituted the foundations of the course and appears in a number of curricular frames: e.g. one of the courses offered was "Educational Implications of History and philosophy of Science". The courses at the graduate level include Invitation to History of Science, Introduction to History and Philosophy of Science, Contemporary Philosophy of Science, Science and Technology Education, Studies in Technology and Society, Perspective in Science Education, Introduction to Philosophy of Science and Technology, Science, Technology and Society Studies and several others. Several of the older courses were possibly modified and resurfaced with a new title as is evident from a perusal of the list above. However, since our focus is not graduate education we shall not discuss the matter further.

## 3. Conclusions

### 3.1 An Interdisciplinary Prelude to a Conclusion

This report has taken up the study of courses on science and society because studies of science, technology and society and not STS emerged as an academic field more than three decades ago in response to the growing need for a comprehensive understanding of the societal context of science and technology. This need was an outcome of the collapse of the optimism of the 1950s in the 1960s and 1970s produced by the negative externalities encountered on a global scale [Elzinga and Jamison, 1981; Cutcliffe, 2000, p.

16]. This produced an interdisciplinary and "issue-oriented and activist field of study" simultaneously dedicated to understand and appropriately respond to the complex issues precipitated by the modern culture of science and technology [Raina, 2003; Visvanathan, 1997]. Over a period of time changes in the field called science, technology and society was accompanied by changes in cognate but discipline oriented academic fields of study namely the history of science and technology, philosophy of science and technology, and sociology of science and technology – in all six academic fields of study. These developments included a critique of traditional notions of objectivity emphasizing the "value contingent" nature of science and technology [Cutcliffe, 2000, p.17].

The important point to realize here is that two distinct phases in the study of science and society must be distinguished. The phase from 1950 to 1970, and the phase after 1970, that for the sake of generality continues into our own times. In the first phase, studies of science and society were inspired by a history of science whose disciplinary roots were traced back to the early years of the 20$^{th}$ century [Thackray and Merton, 1972], but this discipline underwent rapid institutionalisation during the 1950s and 1960s. At the time in addition to the Marxist perspective extant in UK and the continent, Koyré's perspective of science as "an intellectually abstract and theoretical search for truth" was particularly influential. During the years of the Cold War the purported ideological neutrality of science clothed methodologically in internalism [Denis, 1997] could it was thought attract students to careers in science and promote scientific values amidst the public [Cutcliffe, 2000, p.25]. The second phase commences in the 1970s – where we begin to see border crossings and the history of science became more social and the sociology of science became more historical, thereby drawing on the insights of both fields and often blurring disciplinary boundaries [Cutcliffe, 2000, p.25].

Conceptually, curriculum developers predisposed to the idea of interdisciplinary research need to distinguish between the idea of interdisciplinary research and interdisciplinary studies education [Klein, 1990; Klein et. al, 2001]. In any case during the process of developing a curriculum for an interdisciplinary studies programme again developers need to reckon with the circumstance that there is a continuum that extends from multdisciplinarity to interdisciplinarity to transdisciplinarity [Cutlciffe, 2000, p 45]. Studies seem to suggest that the formula for developing existing successful interdisciplinary fields (e.g. biochemistry) is not to challenge the underlying

epistemologies and methodologies of the constitutive disciplines [Cutcliffe, 2000, p.46]. Within the Indian context the field of science and society studies (again not STS, which is too culturally loaded a term) could be seen as a meta-theoretical interdisciplinary formation that amalgamates contextualist approaches bound together naturally by the idea of seeing each of the constitutive terms in context.

However, at institutes of science and technology there could be several modes of interaction between the science disciplines and the social science faculties. The most natural one encountered is the isolationist one wherein each of the disciplines and sciences pursues its agendas without the need to converse with the other ones and peacefully coexist under the same organizational umbrella. The other one is a more conflictual one that is parasitic upon the hierarchy of disciplines that defines several cultures of organizing academic work within the disciplinary sphere, and upon stereotypes of "other" disciplines that circulate within different types of academic organizations. University life is often characterized by a combination of these modes. In such a situation we need to be sensitive to how the conversations (and/or integration) between the sciences and social sciences are broached at the level of the curriculum. The "Science wars" was a manifestation of the deprivileging of scientific authority characterised as accurate and objective [Cutcliffe, 2001, p.61]. Gross and Leavitt and the scientific community in India in the 1980s construed any interrogation of the idea that "science works" as a challenge to science's authority[8]. While scientists are ready to subscribe to a form of weak constructivism, which in any case was an invention of physicists, the real issue appears to be epistemological scepticism or relativist critique [Cutcliffe, 2001, p.62].

As a result science educators inspired by science and society studies press for reform in different ways. Some of them prefer "history and philosophy of science" (HPS) since it conceptually distances itself from cultural and contextual interpretations of science – leaning strongly towards the view that science is a rational enterprise, employing concrete case studies to humanize the sciences. On the other hand, the current fascination with "science, technology, society" (STS) in addition to its fashionable standing like "cultural studies", concerns itself with exploring how science and

[8] For one account see [Nanda, 2004].

technology work and their impact on society, but is undecided about the goals of STS as a cognitive movement. This exploration is premised on a sociocultural understanding of science and technology drawing upon very specific methodological tenets. This means that the methods of the traditional social science and humanities disciplines are applied to the study of science and technology. One of the outcomes of this commitment is a central interest in not only science in the making but contemporary policy issues impacting upon society and training future societally responsible citizens. This prepares a scientific citizenry to the gamut of societal problems engendered by science and technology. But equally important, but currently less, stressed is that it promotes a philosophical and social theoretic reflection upon the "profound crisis of modern life and thought to which S&T have contributed" [Winner, 1979, p. 65].

### 3.2 Conclusions of the Study

We come now to some concluding remarks about this engagement with "science and society" over the last four decades in the context of undergraduate teaching in science and engineering courses. The comparison between the programmes developed at Indian universities and the Indian Institutes of Technology reveals a great deal about institutionalising a discipline and sustaining disciplines in different contexts. A reflection upon the nature of a discipline and the social context of science and technology in teaching programmes was first introduced at the University level. The inspiration for this initially dates back to the report of the Kothari Commission and its engagement with the need for the history of sciences a decade earlier. Subsequently Prof. Yahspal as Chairperson of the University Grants Commission and his predecessor at the Commission the historian Professor Satish Chandra pushed hard for developing courses on science and society. Both also attempted to get the interdisciplinary formation, the social studies of science installed within university curricula. These efforts did not materialise in substantial programmes for two plausible reasons. One it was possibly felt that a teaching programme could be developed without the encouragement and inspiration of researchers in the history and philosophy of science. The important issue was to get reasonably authoritative course material ready and the college teachers would transmit the requisite knowledge from generation to generation. The second reason was that the courses were either pass courses or were to be audited, which possibly signalled to the students that they were not to be taken seriously. Consequently, the courses did not provide a context to their scientific learning.

It has already been pointed out that "science and society" has different meanings at different historical moments and periods. The impulse to teach "science and society" in the 1960s was not to integrate the two or resolve the dichotomy of two cultures, but to provide students of science an understanding that:

[1] history matters even for the sciences,

[2] science is exceptional in its method, but yet it is socially located and its advance can be impeded or catalyzed by forces within society. This appreciation was essential both for the future of science and society.

The idea that "history matters" for the present of science was, paradoxically enough, essential to the legitimation of science as much as it was to jettison science from the musée imaginaire within which it had been confined by positivist ideas of the sciences. Secondly, within the reign of scientism that marked policy making during the Nehruvian decades the pedagogic objective was to lodge science within the centre of contemporary culture. This would, it was thought, ensure the success of the projects in social engineering that the Nehruvian state had taken upon itself.

During this period science education and policy in India was marked by the presence of physics and physicists. In a manner of speaking this was a global phenomenon of the times. Almost till the 1970s "science of science" studies and the "social studies of science" was globally marked by the presence of physicists. In the wake of the debates on relativity theory and quantum mechanics that had revolutionised the modern scientific and cultural imagination, physicists tended to draw intellectual capital from this state of philosophical reflection and anticipation. One of the consequences of the debate on the philosophical foundations of quantum mechanics was that it was extrapolated into concerns of the philosophical foundations of the sciences.

As far as Delhi University was concerned the environment at the level of policy makers and teachers was quite in tune with the times and manifested itself in pushing physics teaching in a number of innovative directions and fields in the 1970s including the inauguration of the Hoshangabad Science Teaching Programme, and within Delhi University itself the creation of the Centre for Science Education. On the down side a number of logistic factors very typical of large universities led to the closure of a number of these programmes. The paucity of good teachers and teaching material was a

major hindrance. From the perspective of the students the awareness gradually spread that even though the course was compulsory and only a pass grade was required the use of standard cyclostyled material was sufficient to clear the course. In other words the students did not find the course inspiring. Speaking to a number of senior professors in the university who attended the course, none of them could recollect anything memorable about the course.

One of the important issues science educators had to engage with was to infuse science teaching with some critical reflection on the methods of science. In order to overcome the lack of a critical pedagogy and appreciation of the nature of science the promoters of "science and society" programmes found no other option than to introduce courses on scientific method and scientific practice at the expense of those aspects and debates of the philosophy of sciences that had animated the field since the 1960s. The logistic problem confronting science teachers was that the field was itself interdisciplinary and rapidly changing, and moving into the most rapid phase of its institutionalisation between the 1960s and 1980s. As a result there was a paucity of professionals in the field who could have undertaken the teaching programme. The dearth of professionals in this interdisciplinary field and the reign of dilettantism within the university context resulted in courses that were rigidly and perhaps unimaginatively structured, contrary to the intentions of those who recognised its importance, when the need of the hour was flexibility and the ability to respond intellectually to social and political context. Even the most innovative courses that emerged from the womb of the department of physics Delhi University failed to find an echo simply because it did not resonate with the university's academic vision. The larger question was that within the small communities of historians and philosophers of science in India there did not exist any consensus about what should be taught or how. At least as far as the history of sciences was concerned the social dimensions were squarely underemphasised and there was no agreement over methods, historiography and the objectives of the history of science –

national pride, understanding the dynamics of the growth of scientific ideas or didactics.

At the Indian Institutes of Technology, the departments of the humanities and the social sciences were established and running before the courses on the social studies of science were created. In fact the origins of these departments date back to the creation of the IITs themselves. This was part of the IITs attempt to incorporate the liberal culture of the university within the structure of an elite polytechnique. The humanities and social science departments were initially considered, as were some of the science departments, as service departments to the engineering faculties. But as happens within any academic context, gradually these departments developed their own post-graduate teaching and doctoral programmes and acquired an independent academic agenda of their own, even while they continued to provide the "social" and "cultural" instruction that was part of the undergraduate curriculum.

By the late 1970s and mid 1980s most IITs were running programmes on the history, philosophy and sociology of science. The "relative" success and continued existence of these programmes must be ascribed to a combination of factors. In the first instance, the IITs were endowed with libraries that were adequate even in the social sciences, partially having to do with the presence of a small number of doctoral students and their requirements. The courses, by the 1980s, were developed by professionals in the field several of whom had done research either in the philosophy of science or the social studies of science, either abroad or in India through the IIT system itself and returned to the IITs to teach. Some of them had studied at Delhi University and then went on to inaugurate cognate disciplines of the social studies of science at the IITs.

Nevertheless, these programmes were also developed by faculty who were employed in the faculty of sciences or engineering, had a deep interest in the subject, and were deeply committed to understanding and promoting ideas of the social relations and rootedness of scientific ideas. In fact, no account could be considered complete without the mention of the names of some of the legendary teachers from IIT-K –A.P.Shukla and P.R.K.Rao. As the legend goes, a large number of students audited the courses rather than register for it, because both teachers made it clear that it was as hard to get a good grade in this course as it was in quantum mechanics or in stochastic processes. Both

these teachers inspired generations of students some of whom went on to make the social studies of science their career. Similarly, Sadanand Agashe (also an electrical engineer by training) and Amitabh Gupta at IIT- Bombay were reputed for the course they taught on the philosophy of science. IIT Delhi too had accomplished researchers teaching courses on science, technology and culture. These courses on the social and cultural dimensions of science and technology provided the faculty members a means to branch out and explore in their own research equally rich aspects of culture. In other words the teaching programme had a positive feedback into their research activities. This appears to be the ideal situation for building a discipline, by manipulating the positive feedbacks between teaching and research.

The flexibility of revising a course, year after year, once approved by an appropriate council of the university is currently available within the structures of the IITs and JNU and in my view arises from the relative autonomy, constantly under threat, of these institutions. While pointing this out it must be recognised that these institutes have low student strengths compared with the gargantuan universities. Student evaluation is undertaken by the course instructor who sets the exams for the students registered for the course, unlike the university system where the student is a faceless entity confronting a faceless examiner. Despite these structural differences the IITs and JNU are able to fruitfully appropriately utilise the opportunities the structure has to offer. For example, since several of the teachers have a background in the sciences, and then either as autodidacts, or through professional training have acquired a more than reasonable professional competence in the social sciences, they are able to maintain a currency and topicality of the courses that are being offered – which of course goes down well with the students and dispels any sense of irrelevance of the courses that are on the menu.

Secondly, the advantage of an interdisciplinary appreciation, both of the science and social sciences enables a sensitivity to scientific, epistemological and social context that later proves advantageous in responding to the "kultur kampf" that erupts from time in the academic world. Furthermore, recruiting competent faculty and then asking them to develop courses on their own which are then reviewed by the wisdom of the greybeards gives the faculty members themselves a sense of ownership of the course. Once these courses have been passed the faculty member is then free to experiment from year to year, editing older versions or censoring outdated texts or theories,

bringing in newer ones or much later splicing in portions of older materials that have been edited out, depending on context, without having to rush back to the committee of professors or the curriculum committee too approve every minor modification in the curriculum. This sense of ownership and freedom to innovate within the course structure is of the essence of a good curriculum.

If we as authors of this report are allowed a personal remark, within the current structure of Indian higher education we are quite sceptical about the ability of specialised institutes to nurture a sense of democratic citizenship, political dissidence or multicultural sensitivities. We say this because the current notion of specialisation in research institutes in an important way runs against the idea of knowledge embedded within the university as communitas – a collegial circle of the educated. Research institutes have more focussed objectives than universities, and students who come to these institutes lead the tiger by the tail inasmuch that they have equally focussed objectives and special requirements. Devoid of a sense of bildung, the path to technocratic utopia is well defined. Sanil has informed us that most IIT students if offered a choice of course in the social sciences would opt for courses on econometrics and modelling that would enable them to model the stock market given their familiarity with computational methods.

While science educators need to engage with the fallout of the three cultures divide, even for the practice of science itself, and not merely in terms of revising the knowledge ideals of science, our fear about integration as opposed to cultivating interdisciplinarity is that the former overlooks the dangers of subsuming `a real difference under an assumed unity'. Interdisciplinary dialogue could result in something transdisciplinary but needs also to ensure that the rigours and virtues of the discipline are perhaps not lost. Ashis Nandy once proclaimed, given the nature of the problems we work with "we are interdisciplinary by default".

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