Strategy Paper

On Integration of Natural and Human Sciences in Science Education

Prepared by the Higher Education Cell, CSCS

Contents:

SECTION I

Integrated Science Education

The Integrated Science Education emerged from the understanding that one of the problems haunting higher education in our country was the strict separation between the study of natural and human worlds leading to two cubicalized domains of knowledge – the natural and human sciences – which are in turn internally "dominated by striations of expertise with deep chasms in between" the transcending of disciplinary boundaries. The Initiative proposes a model of integration (a step beyond inter disciplinarity). Integration attempts in the country are not new but haven't been successful in bridging this divide. The initiative proposes a model that moves beyond the problems faced by the old:

1. One needs to introduce human sciences in relation to what was being taught in science-technology spaces and not in isolation. One also needs to engage with the life worlds of the students.
2. Critiques of science are seen with suspicion by natural science students; critiques, if at all, need to be located in the context of reflections on the historical moorings and philosophical foundations of science-technology.
3. One needs to take a leap in terms of interrupting existing disciplines/methodologies so as to produce integrated knowledge – knowledge that is neither exclusively natural nor human science.
4. A new model represented in terms of the generation of integrated research themes – themes that presently require both natural and human science inputs and that beg the development of a new methodology – a methodology transcending given natural and human science methodologies.

SECTION II

Strategy Paper:

On Integration of Natural and Human Sciences in Science Education

BACKGROUND AND CONTEXT

The **Integrated Science Education (ISE)** initiative of the **Higher Education Cell, CSCS**, Bangalore began work in 2008 on 'science education' in India with the understanding that one of the problems haunting higher education in our country was the strict separation between the study of natural and human worlds leading to two cubicalized domains of knowledge – the natural and human sciences – which are in turn internally "dominated by striations of expertise with deep chasms in between" (Report of 'The Committee to Advise on Renovation and Rejuvenation of Higher Education', 2009, popularly known as the Yashpal Committee Report).

We were confronted with an education system afflicted to this day, by separate and near-opposed methodologies for natural and human sciences, methodologies that are not even in dialogue – a system imparting narrow and limited training in the respective methodologies that allow for only certain kinds of knowledge to emerge, knowledge that is inadequate to face the exigencies of a rapidly changing world, a world in which reality is not strictly compartmentalised into material, biotic and human realms, but in which the realms are continually coming closer and developing overlaps. In this scenario, the ISE initiative felt that one now needed an integrated explanation-interpretation of such reality; why one would need an integrated explanation-interpretation as against a cubicalized/divided/segregated one would of course have to be argued for; one would have to argue for the necessity and benefits of such integration in the context of science teaching

institutes (see Appendix I for the initial Concept Note of the ISE initiative and Appendix II for the Vision Statement and the IISER Project Proposal that has driven the work of the initiative in the past two years; there have, however, been a number of conceptual shifts and detours since the writing of the initial Concept Note and Vision Statement; the Strategy Paper stands testimony to the shifts and detours).

In the past two years, through review of previous attempts at integration, interviews of 30 leading natural and human science scholars, some of whom also delivered talks at CSCS and the Centre for Contemporary Studies (CCS, at IISc) on integration (see Appendix III for a complete list), desk review of existing literature on the (historical and philosophical) separation of the *Naturwissenchaften* and the *Social*/*Geistes-wissenchaften* (see Appendix IV for the PhD level course that brought to the classroom context the 'two/three cultures' debate), critical assessment of courses attempting integration (see Appendix V for the two sets of courses – one, integrating the natural sciences and other, integrating natural and human sciences) the ISE initiative is now in a position to suggest a *model* (and roadmap) for such integration. In the process of arriving at this model (and roadmap) we have closely looked at the multiple ideas of integration and the many arguments put forward in favour of integration so as to now put forward our idea of and our argument for integration.

However, although many science teaching institutes (like the Indian Institutes of Science Education and Research [IISERs]) have now started imparting an interdisciplinary and integrated training in the natural sciences to students, the ISE initiative felt that training in human sciences also needed to be integrated with natural science training; also, the human sciences could not just

be add-on/optional courses; they would need to have convergence and synergy with natural science questions and would have to be relevant and useful to science students.

CONTEMPORARY NATIONAL PRIORITIES

I. National priorities set up by the *Yashpal Committee Report* for inclusive and holistic science education (connecting with social and human issues in the 'real world outside' and integrating questions of the risk-ethics of scientific practice/technological changes) as against cubicalized knowledge were found to be in tune with our concern for integration. The report identified the following as problems of science education in India:

> Standing for more than specific factual knowledge, a scientific outlook calls for an analytical and questioning attitude and the continuous exercise of reason. All this requires us to go beyond specialized knowledge and competence. This universal approach to knowledge demands that boundaries of disciplines be porous and scholars be constantly on guard against the tendency towards 'cubicalization' of knowledge. … The Indian system of higher education has also kept itself aloof from the local knowledge base of the worker, the artisan and the peasant. It has kept itself at a distance from the real world outside. Within the system, there are distances between disciplines. Within a single campus, disciplines often grow in complete ignorance even of each other's presence.

To overcome this, it would be necessary that [science teaching institutions] adopt a curricular approach which treats knowledge in a holistic manner and creates exciting opportunities for different kinds of interfaces between the disciplines, which is unthinkable today in most of the

[institutions] of higher learning. It is also important that [science teaching institutions] relate to the world outside and that the walls of disciplines are porous enough to let other voices be heard. It would thus be necessary that [science] education be seen in its totality and subject areas, as not being designed in isolation". (Report of 'The Committee to Advise on Renovation and Rejuvenation of Higher Education', 2009). In short:

(1) a 'scientific outlook' is more than factual knowledge or rote-learning – one needs analytical and critical skills.

(2) However, what will generate such skills?

(3) Cubicalized/specialized/disciplinary knowledge will not suffice.

(4) One needs to

(i) go beyond specialized knowledge, render disciplinary boundaries porous and develop interfaces

(ii) go beyond laboratory life, relate to the world outside and listen to other voices (here local knowledges and perspectives of recipients/users/stakeholders) and

(iii) in the process generate holistic/integrated knowledge.

However, the ISE initiative felt that one needed to take forward such national priorities in two related directions:

one, the concern for awareness of social and human issues among natural science students needed to be supplemented by knowledge of social and human sciences – thus integration would have to be between sciences – natural and human

and

two, 'what needed to be done' as set up by the report needed to be converted to an actual implementation roadmap which is what we intend to execute at IISc, IISERs, IITs and other science teaching institutes in the coming years.

II. The report on *Higher Education in Science and Research and Development: The Challenges and the Road Ahead* prepared by the Indian National Science Academy (INSA), New Delhi and the Indian Academy of Sciences, Bangalore suggests that India must live up to the "increasing international pressure for knowledge based, value-added development of major areas like pharmaceuticals, drugs, biotechnology, nanoscience/technology, healthcare, genetics, information/computer technology". We feel that integration of the natural and the human sciences so as to produce innovative knowledge solutions to new social problems would be one way of addressing this concern.

The report also states that the first non-professional degree (viz., B.Sc.) by itself is, unlike professional degrees, of not much value or societal attractiveness unless it is of educationally good quality, obtained in a lively research environment, and is supplemented by a professional edge (e.g., additional skill building that adds to employability) or research experience: "Of the large number of such people with a first degree, a small fraction (typically a sixth) goes on to higher degree or research; the remainder, if well trained, [can add] to the knowledge economy in a wide variety of ways. Given the large numbers, their less defined employability and the long gestation period, it is universal practice to have massive public investments for ensuring their quality so that they effectively contribute to a knowledge economy. Our country has, however,

invested much less by international standards. Following the first wave of nation building, the more recent investments have been largely concentrated on relatively small, specialized and primarily research oriented institutions. At this stage, we need a second wave of nation-building. If we embark on this fully, not only will there be a large number of skilled, well-trained, capable, flexible scientific knowledge workers needed both by our economy and by the world, but there will also be a remarkable flowering of research (and development). We must seize this opportunity since otherwise, in the intensely competitive, globalized environment of today, we will at best be spectators, perhaps victims, but not participants".

The report sees investment as one step major towards solving the problems afflicting science education at present. We see integration of natural and human sciences as one other way of increasing the value and societal attractiveness of B. Sc degrees as also putting in place new kinds of skill building and employability options for UG science students.

SCIENCE EDUCATION IN INDIA

This section is an excerpt from the IAS Report on University Science Education: Although the focus of the Strategy paper is science education in the HE sector, particularly at the undergraduate level, it is realized that undergraduate education is part of a continuum, starting with education at the school level and going on to research in science. It is therefore appropriate to remind ourselves, at least briefly, of some facts concerning school, undergraduate and post-graduate science education in India, before going on to reviewing suggestions already made by various individuals, institutions and agencies.

The number of school-going students, about 12 crores in 1985, has been continuously increasing at the rate of about 3% per year. However the number of well-equipped schools, in terms of laboratories, libraries and competent staff, is extremely small. Thus it has been estimated that no more than 60% of schools even have a blackboard, and less than 30% have any kind of library or laboratory facilities. Less than one percent of the students who complete the 10+2 school years go on to science education at college level. While the total number of students in all three years of undergraduate science courses has risen from about 1,28,000 in 1950 to 7,25,000 in the late eighties, the percentage of the total student population choosing science after school has dropped over the same period from 32% to about 19% today. The total university outputs of undergraduates each year, approximately one-third are in the sciences. One can also ask: how many really gifted and potentially creative science students are produced each year in the whole country, who go on to do research and work for a Ph.D. in Indian institutions? A reasonable estimate, based on the collective experience of many academics in their own institutions is that this number is not much more than 150-200. (As an illustrative example, the total number of Ph.D.'s awarded by the Indian Statistical Institute in the sixteen-year period 1979-1994 is about 120.) Typically, the same candidates get selected for admission in all the major institutions in the country for research. Thus the number of students who are suitable and who also opt for research is appallingly small.

Against this background, we review briefly the commonly held and expressed perceptions among the members of the academic community involved in higher education and research about the present state of science education in Indian colleges and universities. There are of course fortunate exceptions, but the general view is that standards in all respects have declined rapidly and alarmingly, and unless something is done soon to remedy the situation the country is

definitely heading for disaster. One quite pessimistic view is that it may already be too late to prevent disaster. On specific aspects of the whole situation, we may summarise frequently articulated views as follows.

a) There has been an alarming drop in the quality of students who opt for higher studies in the sciences after school level. The best products from schools choose to go for courses in engineering, medicine and commerce, the next most talented group opt for administrative services, bank careers and the like those that pursue science at the undergraduate level are then largely drawn from the residue.

b) As against this, there has been no careful assessment of the country's needs for talented scientists in different spheres. The needs are obvious in sectors such as defence, space, atomic energy, health, agriculture and related fields, apart from the universities. The absence of quantitative estimates of the number of persons needed in the years to come may have contributed to the present problems. Well planned efforts to attract, train and retain appropriate numbers of scientists, to pursue a professional career in science in this country, are essential to prevent a crisis in the near future.

c) In contrast to the situation a few, decades ago, students, parents and indeed society as a whole do not presently view a career in science as rewarding or challenging, or even as offering a satisfying professional life. Career opportunities in science are perceived as limited, and as being not at all comparable materially with other professions. Intimately related to these negative impressions is the fact that faculty positions in colleges and universities appear lacking in prestige and respect, and in any case what young people see all too clearly is rampant inbreeding in most educational institutions.

d) The National Science Talent Search awards scheme instituted in 1964 was definitely a very worthwhile attempt to attract the best and most highly motivated students to devote themselves to careers in science. However even here the necessary follow-up steps to retain and provide for such students have been missing. In 1977 this scheme was enlarged to the National Talent Search award scheme, to include areas other than science. By around the mid- to late eighties only about 10% of the total number of awardees were opting for science at the undergraduate level; and the number going on to the post graduate level was even less.

e) It is commonly felt that the maximum damage to our students occurs after they come out of the school system and enter the undergraduate level (occasionally even at the +2 level). It is at this stage that all curiosity, self-confidence, enthusiasm and eagerness to learn are killed. Added to this are poor methods of evaluation and debilitating memory-based examining systems. The products of Indian undergraduate programmes are definitely poorer than their counterparts in developed countries, indeed much more so than at the 10+2 level. The burden of undoing and repairing the damage suffered at the college level has then to be borne by education at the post-graduate and research levels.

f) The options available to undergraduate students entering our institutions today are limited and inflexible. The division into engineering and medical streams at the +2 level itself contributes to the problem. Practically nowhere can an undergraduate student hope to pursue emerging combinations like biology and mathematics or biology and physics. One still has to choose from old-fashioned combinations like Physics. Chemistry and Mathematics or Chemistry, Biology and Zoology. In this respect the situation has

worsened even in the Indian Institutes of Technology, which were initially quite flexible and open in course and subject combinations available to students. The option of students moving from the engineering stream to science is also rarely exercised. With this absurd and self-created inflexibility, a Ramanujan would never make it today.

g) In most universities and affiliated colleges one finds low educational standards and a poor academic environment. Colleges are generally under-equipped, overcrowded and poorly staffed. Not being directly involved in the framing of syllabi or in the evaluation process, it is perhaps not surprising that most teachers become demotivated and are seen to be uninspiring. Questions from students are often discouraged, and experiments and demonstrations are few. Due to lack of experimental facilities, science is taught unimaginatively, and learnt by rote. Generally routine and unexciting topics are taught, basic concepts are poorly covered, and at the higher levels teaching remains divorced from research. Quality and excellence in teaching go unrecognized and unrewarded; the few good teachers there are work under trying conditions. All this has a snow-balling effect – the generally low standards of the output at the undergraduate level get reflected among the entrants to post-graduate education and research.

h) Too many universities and institutions have been established over the years without giving adequate thought to the availability of teachers of acceptable quality. Without any attempts to correct the ills of existing institutions, all too often new ones are created only to face the same problems later.

i) It is widely felt that one cause for the sorry state of affairs outlined above is the government's policy of the past half century of establishing chains of specialised research

institutions and national laboratories outside the university system, without proper and healthy linkages to the latter. This policy, especially the disproportionate funding of these institutions, has deprived universities of both talent and material support. Even worse, the access of young motivated students to leaders in various fields of science – natural in a university setting in developed countries and so essential to creative work at a young age – has become virtually impossible. Thus the soil where scientists of the future should grow has been deprived of some of its most important nutrients.

j) There has been hardly any initiative or involvement by private nongovernmental sources of support towards higher levels of education and research. Endowed chairs, industry-supported specialised laboratories and the like are conspicuous by their absence. This is particularly unfortunate since private enterprises depend on products of the educational system for their own needs.

k) As a result of national-level discussions and suggestions for mechanisms to encourage and support scientific research, many schemes have been established by Government agencies, and these have in fact done quite well. Examples are the Science and Engineering Research Council within the Department of Science and Technology, the COSIST programme of the University Grants Commission (UGC) and the (now-abandoned) University Leadership Programme. However, in the educational sphere, though on several occasions studies and recommendations have been made to improve the situation, there has been no sustained follow-up action. Even the series of teacher-training schools held successfully in the 60's and 70's, with support from the U.S.

National Science Foundation, were discontinued due to lack of support from the Government. As a result, the enthusiasm for excellence in education has been lost.

1) With increasing political interference in higher education, the pursuit of excellence has disappeared and given place, among other things, to commercialisation of education. The twin aims of social equity and academic excellence are being seen as opposed to each other. There is no intellectual debate on these overlapping problems, and it is being left to the judiciary and the political leadership to determine the directions open to society.

From this sampling of frequently heard opinions it is clear that the problems of university science education, seen in totality, are manifold, and that there has been room for continued criticism and complaint. Under these circumstances there is a need to find ways in which one can help identify and reach out to the gifted, save as many of them as possible for the pursuit of science, and make them feel that it is still worthwhile and deeply rewarding to fashion careers in science. Here are some of the solutions offered in the report**:**

(i) At the undergraduate (U.G.) level the basic aim should be to make the spirit and excitement of science come through, so that appreciation for science would remain with the student independently of what he or, she might do later.

(ii) The U.G. course should be solid and broad based, providing a good foundation in at least two subjects, and should definitely avoid specialisation too early. Thus all U.G. students should take some common courses in physics, chemistry, mathematics and biology in the first two years, or perhaps select combinations from a core curriculum so designed that they will be exposed to the fundamentals of these basic subjects; then choose subjects in one or two of the four streams for

the third year. This will avoid variations in levels of teaching in the main and subsidiary subjects. One may reduce the content of each major subject, but no subject would be left out.

(iii) There is often a tendency to sacrifice essential areas of the four major (P,C,M and B) to make room for trendy specialisations such as chemistry, theoretical computer science, and the like; or such "job-oriented bio-courses" as poultry, fisheries, sericulture, etc. These can come later; early specialization at the U.G. stage must be strongly opposed, as it leaves with a weak conceptual foundation which is very difficult to make good later. This is especially true for those students who plan to go on to the postgraduate level and then possibly on to scientific research. For genuinely job-oriented courses, such as the "applied science" options referred to earlier, at least one year of good teaching of fundamentals is essential; this can then be followed by specialisations like those mentioned above, and many others.

(iv) Curricula can never be static, and should be constantly reviewed and improved. In the process, room must always be made for really new subjects, but not at the expense of the foundational courses.

(v) Experimental programmes should lay stress on open-ended exploratory experiments using simple materials where possible. Innovative experiments must be specially conceived and devised for this purpose.

(vi) At the post-graduate (P.G.) level, the first year should concentrate chosen subject with common courses for all students within that discipline. Further specialization, choice of elective courses, and project and seminar work should

form part of the second year, and then preferably in the second term. It is common experience that industry also prefers students who have gone through and common core curriculum, with no basic areas neglected, with specialization coming towards the end of the P.G. course.

(vii) With all four science subjects being offered to all students at the UG level for two years, one can hope to see such fruitful combinations of subjects as mathematics and biology or physics and biology being chosen by talented students at the later stages. The merging boundaries between different disciplines such as biology, chemistry, physics, etc provides one with challenges as well as opportunities. These should be reflected in the course options available at advanced levels.

While integration among the sciences (as suggested above) has happened at the IISERs (see Appendix VI: *Education at IISER*) and shall perhaps slowly take shape even in other institutions and the colleges-universities, we would also like to argue for integration among the natural and human sciences. This will make the "spirit and excitement of science come through, so that appreciation for science would remain with the student independently of what he or, she might do later". Courses focused on the historical moorings of the sciences and the philosophical foundations of the sciences shall give students a "solid and broad based" sense of the context and method of doing science. Students will thus be exposed to the fundamentals of basic science subjects. Courses in integrated themes like environment and cognition for example connecting natural and human science concerns shall help avoid specialisation too early. Integrated courses will also train students in the 'applied' aspect of the sciences.

Summary: Here are some of the salient issues afflicting science education in India:

i. The quality of science research and education needs to be cutting-edge and globally competitive. It has to provide innovative knowledge solutions to complex contemporary issues/concerns. Researcher and teacher competence needs to be both deepened and expanded.
ii. The quality achieved in metropolitan centres like the Indian Institute of Science (IISc) needs to be made available to students in non-metropolitan institutions (UG colleges for example).
iii. Socially disadvantaged students of natural science need to be handheld at the UG level so that they can be retained in higher education (would handholding mean production of natural science material in the regional languages).
iv. Falling enrollment patterns in the natural sciences and lack of employment opportunities of students (do we then need to rethink natural science curricula and attune them to the demands of the job market? Would integration help?)

GLOBAL CHANGES IN SCIENCE-MAKING

Science and technology are among the most positive forces for change at humankind's disposal. Rising public investments in scientific research, science education, technological innovation and the public communication of science demonstrate that many governments recognize the importance of science and technology for socio-economic development. As the industrial

societies of an earlier era evolve into today's high-tech 'knowledge societies', science and technology are regarded as primary drivers of innovation, social welfare, increased productivity and wealth creation. This presents an enormous challenge to poorer countries who, now more than ever before, need to establish and maintain their own scientific capacities if they are to be competitive in the global knowledge economy. Universal and equitable access to scientific knowledge is crucial in bridging the socio-economic divide between the North and the South. Scientific research and exchange have a central role to play in fostering improved communication and shared orientations to problem-solving across political and cultural boundaries. In a rapidly changing world, the Principle of Universality of Science provides an important model of equity, nondiscrimination and cross-cultural cooperation.

Not all of the impacts of science and technology, however, are equally beneficial, nor are they universally seen to be so. Fears have grown in recent years about the capacity of science and technology to intervene adversely in various dimensions of human life – including its origins, its ending, and its physical and social environments. Advances in genetics and the life sciences are particularly disturbing to many because they not only promise to cure disease and alleviate hunger, but also threaten to irreversibly alter human nature, human relationships and the natural environment. Pollution and physical harm continue to be among the unintended consequences of many beneficial technologies such as electronics, pesticides and vaccines. The increasing dependence on fossil fuel based technologies is changing the planet's climate, with very serious implications for future generations. The application and further development of research with the aim of constructing new and more deadly weapons is still being pursued in several countries. New cooperative understandings between science and society are needed to counter-act these

developments and ensure the transition towards more sustainable ways of living.

The internet and world-wide web have not only brought much of the world closer together but have introduced new vulnerabilities. The role of the media, including their use of new information and communication technologies, is pervasive but their impact on social values and cohesion remain poorly understood. More generally, the speed with which scientific ideas are communicated around the world and are incorporated into technology has increased. The consequences of many technological developments accordingly seem less predictable than ever before.

The political context for doing science also changed radically at the turn of the 21st century, with the end of the Cold War, the intensification of global commerce and communications, and the rise of new transnational threats and conflicts. Closer relations between science and industry, often actively encouraged by governments, have called into question the presumed impartiality of science and the openness of scientific communication. New concerns have also been raised about the ethics of research and the accountability of science to its sponsoring governments and publics, especially as more research is conducted across national political boundaries.

The relationship between science and society will centrally influence the directions and practices of science in the 21st century. In order to strengthen science for the benefit of society, scientists need to be responsive to the changing needs and concerns of society; and society, in turn, needs to understand and support the positive role of science. As the move towards a global knowledge economy gathers momentum, with an increasing premium on scientific knowledge and high

technology, the time is ripe for a new international initiative that will advance the welfare of science as well as society.

The relationships between science, technology and society have changed very significantly in recent decades. The most important changes that have implications for the international science community can be grouped under five broad headings:

1. Changes in the mobility and global flows of science and scientists, and associated challenges to universality;
2. Changes in the production of scientific knowledge and the emergence of hybrid (e.g. public-private) contexts of practice, raising concerns about the impartiality of science;
3. Changes in the speed and scale of innovation, producing unavoidable new risks and uncertainties;
4. Changes in the governance of science and technology, especially as a consequence of globalization, creating new demands for expert accountability and ethical conduct;
5. Changes in the nature of expertise on the relations of science and society within civil society, especially among non-governmental organizations (NGOs), and in academia.

Under each of these headings, changing practices and assumptions have revealed inadequacies in existing institutional structures for regulating the relations of science and society. In particular, the self-regulation of science no longer seems adequate to handle all of the pressures placed on scientific integrity. At the same time, national structures alone no longer seem sufficient for ensuring scientific freedom and responsibility at the global level. There is a growing need to ensure global equity in knowledge production and knowledge sharing, including the

identification of best practices in contested areas and the development of consensus principles for data access and sharing. One aim would thus be to enhance the pluralism of science.

The increasing involvement of the private sector and the close ties to policy making in many areas of research are changing the context in which scientific knowledge is produced. There is a need to analyze and deliberate on the possible threats to ethics and academic freedom arising from the new modes of production of scientific knowledge. Information should be developed on the ethical norms and standards that are applied in partnership arrangements for research around the world. As the corporate sector becomes a more significant sponsor of research, there is a need to monitor and enhance ethical practices within industry. The development and adoption of codes of conduct for scientists and engineers, including those working for industry, remains a priority, as does the sharing of information about such codes. Peer review and related evaluation practices remain essential, but their roles within changing contexts of scientific practice are poorly understood. These should be systematically monitored and analyzed. Of particular interest are procedures for assuring the quality and integrity of science produced to support public policy decisions in areas such as health, safety and environmental regulation. The concept of technology assessment needs to be revisited, with regard to: the ethical, environmental, social and economic impacts of technology; cross-national technology transfer; and, the impacts on traditional technologies and other cultural systems. This may require new forms of cross-institutional and cross-disciplinary partnerships.

Science and technology produce not only enormous benefits but also novelties and unknowns that may carry adverse physical, social and ethical consequences. Understanding and fairly

communicating risk and uncertainty are increasingly important for science and society. The treatment of risks and uncertainties in decision-making demands more sustained intellectual analysis and policy attention. Specific questions that should be addressed include: How are uncertainties assessed and communicated in diverse areas of decision-making (environment, public health, engineering, terror alerts, disaster forecasts and inquiries, etc.)? How effectively is existing knowledge concerning uncertainty, particularly from the social sciences, being deployed in decision-making? Are there any major deficiencies in our knowledge regarding uncertainty or in the uptake of existing knowledge by policy institutions? What conceptual and legal frameworks exist for the analysis and communication of uncertainty, how do they differ across disciplines and institutions, and what are their relative advantages and disadvantages? Important examples include risk-based, precaution-based, and evidence-based approaches. What ethical standards exist to guide experts in the representation of uncertainty? Are there best practices in diverse areas of risk or uncertainty analysis? How do publics cope with uncertainty, and how can decision-makers and the media ensure the responsible communication of uncertainty to publics?

The proliferation of risk and uncertainty are increasing the demand for accountability in science. As science and technology pervade more dimensions of life, scientists also have to be more responsive to societal concerns. There is consequently a need for more participatory and transparent governance mechanisms.

The task would be to broaden the educational agenda in science, engineering and medicine and exploring mechanisms to engage the next generation of young scientists more effectively in studying and understanding science-society relations. One would also need to explore methods

of integrating the practices of science and medicine with relevant indigenous, local and traditional cultures and knowledge systems.

Andrew Stirling, who works on Science and Technology Policy at the University of Sussex and who was interviewed by the ISE initiative, suggested that some of science-making and science teaching in the west is beginning to take into consideration and include debates on the 'social context of science'. The process of *doing* science is also showing an increasing readiness towards inter-disciplinarity (though there is still a tendency to treat inter-disciplinarity as multi-disciplinarity, where each discipline has its own divided area and the terms of the trade between disciplines are set by a higher level usually, by a dominant discipline). For him, real inter-disciplinarity in the sciences is when the terms of trade between disciplines are being settled by the disciplines themselves in a more symmetrical fashion; so that they interact on terms they can decide on. According to him what is really lacking in science education today is trans-disciplinarity. Sterling's definition of tran-disciplinarity is when not only do the disciplines deal with each other on an integrated and symmetrical basis, but also when the *problems are set outside natural science*, so that *science is responding to questions of stake holders outside science* (the Strategy Paper marks this outside in terms of both the larger social focused on 'risks'[1] of scientific-technological advances and the industrial focused on 'profit' from similar advances).

[1] Sterling approaches risk through the term *uncertainty*: "my analysis of the word "risk" is that the very word narrows down or tries to treat a problem as something that can be resolved by quantification or by probabilistic analysis. My concern is that a lot of it is not tractable to quantification so we should call it uncertainty" (see Appendix VIII: A. Stirling, "Risk, Uncertainty and Power", *Seminar*, 597, 33-39, May 2009; A. Stirling, "Multicriteria Diversity Analysis: a novel heuristic framework for appraising energy portfolios", *Energy Policy*, forthcoming; A. Stirling, "Science, Precaution and the Politics of Technological Risk: converging implications in

Dhruv Raina, Purabi Pattanayak and Vungliankim Valte in their report (*A Study in the Social Epistemology of "Science and Society" Education in Indian Universities and Technical Institutes* 2009) have called this the need for the "socialization of science" (Nowotny et. al., 2001) in the context of the "third industrial revolution" marked by advances in information technology (as against the post-independence obsession with the "scientification of society" under developmental conditions); so while in the post-independence period it was society that needed science and scientification, at present it is science that needs the social and by default social science.

Sterling further argues that in the context of such a "socialization of science", students are now getting exposed to broader/holistic questions; and this is happening because of pressure exerted by recruitment issues: "Science universities are now finding it difficult to recruit scientists. Among many strategies, they are forced into trying to make science more appealing. In order to make them more appealing they address more inter-disciplinary problems through for instance, Environmental Science *and* science related to industry. These days there are more courses that are paying attention to inter-disciplinarity. They also motivate students as they address social problems, environmental problems *or* because it makes them more recruitable into industry because they have looked into economics and finances as well. The Universities are too captured by disciplinary interests and this is being forced into the science area where the push is to be

---

evolutionary and social scientific perspectives", *Annals of the New York Academy of Sciences*, 1128, 95-110, April 2008; A. Stirling, 'Opening Up and Closing Down: power, participation and pluralism in the social appraisal of technology', *Science Technology and Human Values*, 33(2), 262-294, March 2008; A. Stirling, Deliberate Futures: Precaution and Progress in Social Choice of Sustainable Technology, *Sustainable Development*, 15, 286-295, 2007).

more open minded. ... More importantly, science in Europe sees itself as under siege by critical social forces. The issues usually center on the forces that control science, where does money go, what types of problems it addresses and in particular, public engagement. All these are matters relating to the control and governance of science. However from within science the response to pressure for public engagement is to devolve responsibility to the least powerful people in science – that is the 'individual scientist'. There is a tendency by the powerful scientific institutions and bodies like the Royal Society and various Research Councils, to externalize the pressure to be more accountable onto the individual scientist. Therefore it adds another dimension to science education. Increasingly public engagement, science communication, is being seen as part of a scientist's curriculum". Given such changes in the European scene[2] (focused on the one hand, on the science-industry interface and on the other, on questions of (i) science ethics, (ii) North-South cooperation, (iii) human dignity and human rights (iv) gender equality in science (v) intellectual property and (vi) science for peace [see Appendix VIII: *Harnessing Science to Society: Analytical Report*; *Building trust between science and society: A Scientist's Manifesto*; *Science Shops*[3] *as Science-Society Interfaces*]), how would science

[2] Also, the knowledge society debate is very pronounced in Europe even though it is now considered a less fashionable subject. In Europe the knowledge society or the knowledge economy as it is often called, is actually at the center of the European project. The project for European integration (the big treaties, the new stage of unification between European countries) is organizing around science and technology and innovation. So Europe needs to be ready for this new phase in world history where events are driven by science and innovation and there is a felt need that Europe needs to be more effective because it is losing ground to India, China as well as the United States.

[3] Science Shops give access to those that would otherwise not have access to scientific research. Equitable partnerships are formed, in which research questions are phrased together, and there is an on-going dialogue and constructive interaction for mutual benefits (to society, and to students/researchers and universities). Science Shops are a tool for strengthening democracy by involving citizens in governance of science, and, moreover, empowering them to participate in various decision-making processes where science and technology (can) play a role. Interaction

education in India respond? Perhaps we need a combination of institutional changes, production of new course material (focused on science-technology policy, scientific uncertainty, governance of innovation, public participation in science) and curricular reform to live up to such global level changes.

Summary: Taking off from the above one can identify five issues that are of importance in terms of taking stock of how one 'does' science in the contemporary:

a. **Changing Nature of Scientific Research:** *Data Intensive Scientific Research* (see Appendix IX: *The Fourth Paradigm* ed. by Hey, Tansley and Tolle) consisting of what Vijay Chandru (Chairman & CEO at Strand Life Sciences Pvt Ltd) has identified as the four challenges:

   - The IT Challenge: Storage, Computing
   - The Computer Science Challenge: Algorithm design and implementation
   - The Mathematics Challenge: Statistical Analysis, Systems Theory
   - The Multi-Disciplinarity Challenge: Contextual problem solving

b. Changing Interfaces of Science:

(i) The Society Interface

(ii) The Industry Interface: Research Commercialisation – Roles of University Spin-Offs at the University-Industry Interface

---

between citizen groups and researchers can have more profound, long-term influence on the scientific process, by changing the focus of research.

University's traditional paradigms to generate, perpetuate and disseminate knowledge are undergoing progressive shifts since the inculcation of research commmercialisation idea. Conventionally, universities were allocated public funding to pursue research and development (R&D) while the privilege of picking research agendas in accord of nation's interests was handed to scientists. Nowadays, strategic partnerships between university and industry are growing to facilitate the flow of research outputs from lab s into marketplace. Ac accordingly, applied research is gaining favourable attention over basic research, while scientists, conventionally known for their knowledge quests and non-meddling stances in commercial activities, are strongly urged to accommodate entrepreneurial approaches to advance further in career, as well as to give proprietary research a priority. These scenarios illustrate the increasing influences of research commercialisation towards university's affairs worldwide; thanks to its potentials as an alternative revenue streams and as a key player in the global economic race.

(iii) **The Human Science Interface**: the diagram below gives a sense of the human science interface in terms of the 'tree of knowledge' –

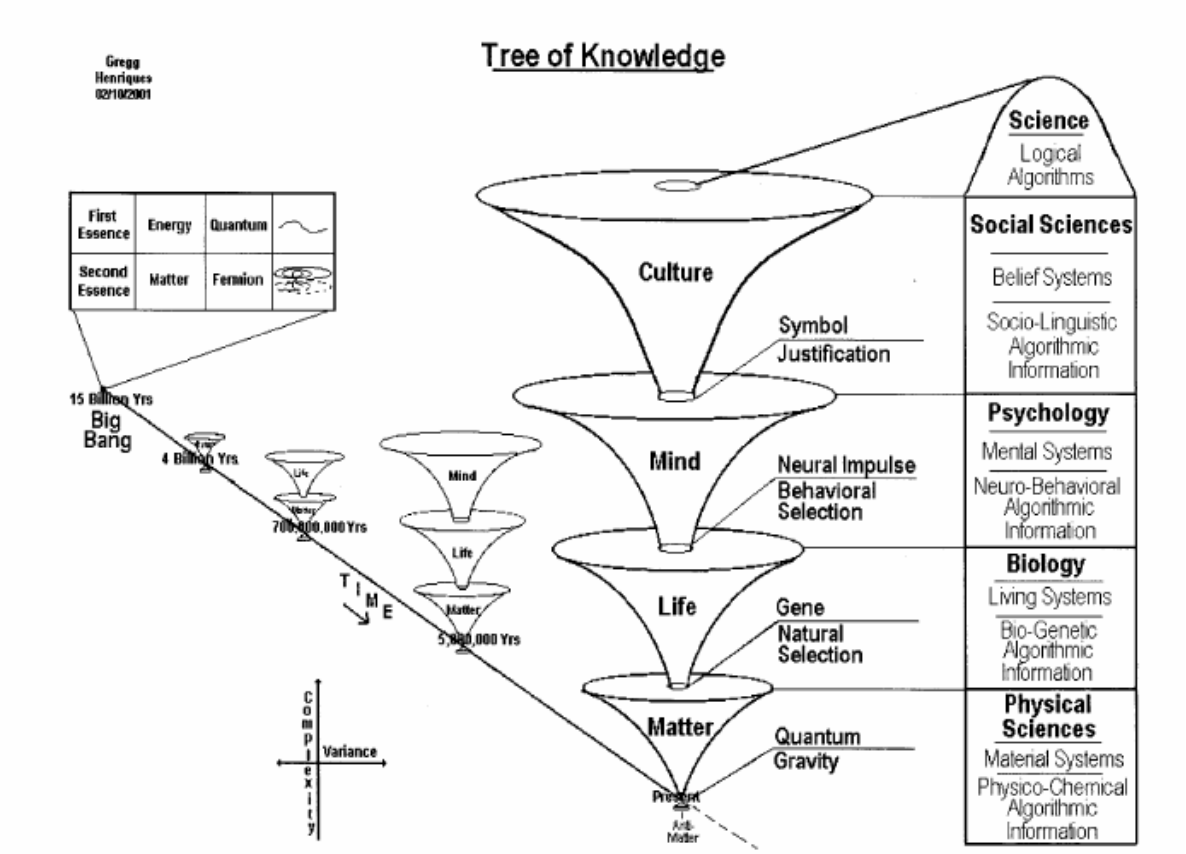

Figure 1. The Tree of Knowledge system.

(iv) **The Policy Interface:** Here the suggestion is that integration could provide a 'knowledge ecosystem' – a means by which the social, cultural and economic benefits of HSS research percolate through various two-way channels to a wide range of beneficiaries, who also inform and influence the shape and direction of HSS research. The process is not linear; research beneficiaries do not passively receive information from research producers. Rather, researchers and beneficiaries interact and will often work together to identify problems and the means of overcoming them.

FINDINGS OF THE ISE INITIATIVE

The work of the initiative consisted of research in three areas – respectively focused on what have been the problems of natural science education in India, why we need to integrate natural and human sciences in our pedagogic efforts, and how one can go about integrating them in science education institutions (like IISc, IISERs and IITs). The findings of our research in these areas are summarized here:

(1) The Idea of Integration: The first area of the research has concerned itself with what 'integration' itself means. Attempts at integration are not new to science education in India; although the use of the term 'integration' is new (Dhruv Raina et al show how in the space of science-technology education in India, economic, political and cultural questions have come up from time to time since the 1960s. Indian science and technology has not managed to remain altogether immune to nationalist and developmentalist questions. It has participated in the fostering of a scientific mindset among the Indian populace (when "scientification of the social" was the prime obsession). At times it has also had to engage with questions of the ethics of scientific practice (questions of medical ethics and the recent controversy over bio-technology products is representative). Research conducted by us through

a) revisiting crucial texts on the 'science'-'technology' question (see Appendix IV),

b) study of science education reports (see Appendix XI for a complete list of reports),

c) feedback obtained through interviews from key figures in the natural and human sciences (see Appendix VII), and

d) stock-taking of existing HSS and integrated course in IITs and science teaching institutions,

revealed that we were working with multiple meanings of integration. The Strategy Paper therefore needs to come up with its distinctive understanding of integration. This is also important because the research took off from the framing argument that we could not just add on existing humanities and social sciences to science teaching institutions. Also the conceptual space marked under 'humanities and social sciences (HSS)' have gone through fundamental changes in the last few decades, which is why the question "*which* version of the humanities and social sciences is to be introduced" is a question worth pursuing. Further, one needs to keep in mind *where* the humanities and social science concerns, questions and methods were being brought in. The form and content of HSS courses and the context of teaching of such courses were found to be crucial.

In its bid to mark the distinction between integration, trans-disciplinarity, inter-disciplinarity and multi-disciplinarity, the Strategy Paper looked into each in detail (see N. J. Rao, 2009).

Klein and Newell (1997) define Interdisciplinary studies as a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession and draws on disciplinary perspectives and integrates their insights to produce a more comprehensive perspective. Boix Mansilla and Gardner (2003) of

MIT define interdisciplinarity as work that integrates knowledge and modes of thinking from two or more disciplines. Such work embraces the goal of advancing understanding (e.g., explain phenomena, craft solutions, raise new questions) in ways that would have not been possible through single disciplinary means. The National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine define interdisciplinary work as a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice (National Academies, 2005).

Multidisciplinarity refers to the placing of side by side, two or more disciplines, for example, one might find in a course aspects that invite instructors from different departments to explain their discipline's perspective on the course topic in serial fashion but make no attempt to integrate the insights produced by these perspectives into an interdisciplinary understanding of the topic. Here the relationship between the disciplines is merely one of proximity; there is no real integration between them. Multidisciplinarity is entirely subsumed within interdisciplinarity; it is a necessary but not sufficient condition for interdisciplinarity.

The disciplines are foundational to interdisciplinary research because they provide the perspectives, epistemologies, assumptions, concepts, theories, and methods that inform our ability as humans to understand our world (Repko, 2005). Students demonstrate interdisciplinary understanding only when they *integrate* knowledge and modes of thinking from two or more disciplines (Boix Manislla and Gardner, 2003). The disciplines, though necessary and

foundational to interdisciplinary work, are not the sole or primary focus of the interdisciplinarian's attention; the focus is the complex problem or intellectual question that is being addressed. The *disciplines* simply *serve as a means to that end*.

These definitions of interdisciplinarity reflect four core elements:

- addressing complex problems and focus questions
- drawing on the disciplines
- integrating insights
- producing a new understanding of the problem; this could also give a different perspective on the world

Raina *et al* have represented the above discussion in terms of the methods and objectives of the triad of multi-, inter- and trans-disciplinarity:

Knowledge form	**Methodology**	**Objectives**
Multidisciplinary	Juxtaposition of traditional disciplines	Gain an insight into a problem
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

Given the above triad and the constraints (both institutional and epistemic) the Strategy Paper would like to put forward its own understanding of integration that could be attempted (at present) in existing science teaching institutions. Here are the two possible forms of integration:

(i) The ‘soft programme’ of integration (0ne could also call it the ‘dialogic model’): this is premised on the ‘university model’ of having an open-ended menu that is offered to natural science students. This will be bringing existing disciplines and their respective methodologies to dialogue without overtly challenging one another. Understanding each other’s perspective/standpoint and seeing the promise in the ‘other discipline’ is the key to the success of the soft programme. The soft programme is therefore ‘pedagogy heavy’ (classroom contexts, talks, workshops, seminars and conferences could be the key components in this programme; integrated research would only be a fall-out or consequence of this programme). The CCS-IISc model is for us, an example of the soft programme. From the point of motivations, there are four that guide CCS-IISc at present (Raghavendra Gadagkar(*Gadagkar is INSA SN Bose Research Professor and JC Bose National Fellow at the Centre for Ecological Sciences, Indian Institute of Science, Chairman, Centre for Contemporary Studies, IISc*, ***)*** reflects on the four in his interview):

1. “CCS-IISc responds to the fact that we live in disciplinary islands and something has to be done to *step out* of these islands, however small”.
2. “At IISc there is no possibility of even having coffee with someone doing something else. Here there is much greater isolation. There are no opportunities for social or non-technical interaction. CCS wants to know what a person doing research in music looks like. It is a matter of great frustration that one doesn't even casually run into someone else. One begins to believe that the whole world does the same thing as one does. Students at IISc become part of this belief and they spend their five years in complete isolation, as if there is no such thing as

another discipline. CCS wishes to *expose* IISc students to hitherto unknown others".

3. "CCS also wants to explore the question: what is 'science' in the contemporary and in India? How does one do science now? Natural science research is increasingly becoming a sophisticated, expensive, and technology-dependent interface; which means that there is greater resource- or allocation-level disparity between different people and countries, between universities, between labs, and in one's ability to do science now and this has nothing to do with one's intrinsic competence. It has to do with externalities. This is a serious matter. Perhaps it is not as important in say literature. In the sciences, the playing field is very uneven because of this dependence on technology, infrastructure, and money. It is not that the intrinsically competent will come up with something worthwhile. We are not going to get a noble laureate from Tumkur University easily. Why? Not because there are no intrinsic abilities in Tumkur. Intrinsic abilities are randomly distributed in the world (even in Tumkur there is a potential noble laureate). But the other factors (like funding, instruments, and technology) are not randomly distributed. There are concentrations and rarified zones in terms of their distribution. People who are not placed in the most endowed situations (like Harvard, Amherst, IISc or even Bangalore University) have to *find other ways of getting ahead* (here the dialogue between natural and human science disciplines could be important). In Natural Science, this would translate into having a different perspective on the same problem. Design an experiment in such a way that MIT shall not do; because he has his path set. Buying the same kind of

equipment that the MIT scientist has will not solve the problem. He will always be one step ahead. Trying to run faster on the same track will certainly not help Indian science. So to overcome this (infra-structural) limitation we shall have to take a detour, and look at the world from the other side. Exposure to other disciplines will usher in this possibility. So that people in underdeveloped countries can compete with their developed counterparts. Training or at least exposure to human sciences (and their methodologies) can end up giving the Indian science student a fantastic perspective, an epistemic clue that his or her western counterpart shall not have (even while having access to the best labs, best equipments and best technological support). This is what CCS is trying to at IISc in a somewhat modest way by bringing natural scientists and human science scholars to dialogue".

4. "The most ambitious of all the CCS attempts is to create conditions for the questioning of the foundation of ones' own discipline. Questioning the foundation of one's own discipline is intrinsically hard, even practically difficult because one is always competing with everyone else. It is easier to build one more floor to the existing structure than to bring down the foundation. How does one even begin to institute a critical/contradictory edge-wedge in the seamless solidity of the foundation? While it is hard to question one's own discipline, one can question the foundation of someone else's discipline. There are two reasons for this. One, the cost is much less as one is coming as an outsider. Two, familiarity with one's own foundation blinds one to different ways of doing work within one's own discipline. Questioning the foundation of someone else's discipline may

> inaugurate an accidental wedge in one's thinking through which one becomes aware of one's own disciplinary base. One then begins to *reflect on the foundations of one's own discipline*. CCS wishes to create conditions for such self-questioning".

(ii) The 'strong programme' of integration: this is premised on the model of focused research programmes (one could also call them 'integrated themes'; here two disciplines come face to face and interrupt each other in such a way that a *third* (what we call an integrated method) is born. Here the fidelity is to the problem (not to the discipline). One is looking for a solution to the problem (and not necessarily a disciplinary solution). This also requires a questioning and critical reflection on the accepted foundation of one's own discipline. If necessary, if the nature of the problem demands it, one may even need to overturn such foundations (as in 4. above) and look for radically different perspectives. Maybe the problem will not be tracked or tackled without such an overturning.

(2) The Necessity of Integration: The second area of research consisted of an investigation into the reasons behind or necessity of the integration of natural and human sciences. Why should we integrate human and natural sciences? Is there some purpose to integration beyond being merely ethical and progressive? What are the advantages of integration for the institution and to the student? It is not only to present the human dimension to natural science students and make the next generation of scientists more humanitarian. Awareness of the social, and knowledge of social science, although deeply connected, is not the same. Social awareness does not necessarily translate into

knowledge of the social. At times integration gets reduced to awareness of social and political issues amongst science students. However, given the historical separation, what we are looking for is integration of natural and human sciences, their knowledge frames and their methodologies. The human sciences are not just about larger societal and cultural values but are distinct knowledge domains. Knowledge of such domains would give rise to socially relevant and responsible science research and education. Integration is thus not about the value education of science students but about opening windows and creating conditions for new kinds of science research and education. There is of course no reason to believe

Several arguments can be (and have been) put forward in favour of integration by leading natural and social science scholars:

(i) Since reality is complex and quasi-natural spanning brute materiality and intentionality, natural science alone is not enough to capture all of reality. We need a holistic/integrated view to widen the horizon of knowledge and add to natural science spaces, human science inputs.

(ii) The inherited divisions of fact/value, sensory-experience/lived-experience, objective/subjective, universalism/contextualism, explanation/interpretation has been a hindrance to knowledge production – we need to move beyond these binarisms.

(iii) A good scientist is one who can critically reflect on one's own discipline (and its methodology) as also connect with other disciplines. We therefore need to train them in the historical moorings (through history of science), philosophical

foundations (through philosophy of science) and sociological bearings (through sociology of science) of scientific knowledge.

(iv) Science education should have courses on Indian culture and the tradition of science and technology in India so as to make them relevant to the Indian context.

(v) Human science inputs are also needed in a largely techno-scientific and mechano-morphic milieu of dry rationality, laboratory exercise and experimental experience to produce responsible and accountable citizens attuned to larger societal/national issues and questions of value-ethics.

(vi) Scientists are also future planners and administrators which is why they need to be aware of developmental and globalization debates.

(vii) Scientists need to be aware of larger forces like global capital and funding that in turn shape scientific research and laboratory activities and science students need to be made aware of the economic and political context in which science and technology takes shape.

(viii) The consumers/users have a close relationship with scientific and technological changes. At times such changes subject humans to risks and scientists need to be aware of this. They also need to take note of and represent the consumer/user's perspective (like that of the peasant/patient) in science education.

(ix) Scientists need to be aware of the social risk of technological changes (like global warming and e-waste).

(x) Scientific and technological changes come with ethical questions (like cloning) and they need to accommodate an awareness of these issues in science education.

(xi) The next generation of scientists need to be more humanitarian (one needs to make them aware of the dark side of nuclear weapons).

(xii) One needs to interrupt natural science education with knowledge of human science methodologies; such interruption could give rise to new perspectives/methodologies.

Here it would not be out of context to foreground Satyajit Rath's ideas on integration; such ideas can help bring more complexity and depth into the practice of integration. Rath feels that shortcomings on the part of science students are not caused by a lack of integrated education. They are caused by larger social, cultural, demographic, political questions and frameworks: "A large number of natural science students come from a middle class or an aspiring middle class context. Positions they take are derived from their life experiences and life situations rather than by presence or absence of integrated education". One therefore has to take into consideration the *life worlds* of students and cater education to engage with such life worlds. Rath thinks that integrated education is of value and will contribute to some knowledge. However, he is not sure whether it will be filling some lacuna or changing an educational problem. He thinks it will be a remedial add-on. No radical change will be instituted as a result. Looking at science education from an integrated perspective is of value but since the problem does not arise in the classroom expecting the classroom to make a large bent in the problem will be an over-expectation. Part-time teachers in UG education and the mediocre quality of teaching is another problem. Also, a

great deal of scientific research in India (especially in his field: biology and life sciences) is mediocre. It is a *crisis of competence* (in being able to teach, in being able to research): "If you are a poor teacher, if you don't know your subject particularly well, if you are not sound in your subject then you invariably prefer to walk down the path of closed spaces for your teaching where you do not need to connect with topics you don't know more about. I think the lack of connectivity is an outcome of lack of competence. What I am arguing is applicable to both natural and social sciences. My further argument is that integrated science education is valuable but we don't need to invoke the current dire stage of higher education in India as a justification for introducing integrated education, because integrated education is not a solution to that. Also, the idea of integrated scholarly perspective is not primarily intended to create better citizens; I think the byproduct will be the creation of better citizens. The question is whether the outcome is at odds with deep disciplinary scholarship or is it not? My answer is that if what we are trying to provide is a sophisticated, scholarly perspective then we are actually adding value to the capability of students to undertake even domains of disciplinary work. … One other way of looking at integrated education is to see it as an *explicitly political project*. All this talk about 'better citizen' and 'value education' leads to this conclusion. It's not about writing something on a blank slate. We are attempting to undo attitudes that we think are making them bad citizens. But out there in the real world of India, there are very large numbers of adults who are the democratic backbone of this politics. So I have no problem with undertaking a political project (see Appendix IX: In the Grip of the Python: Conflicts at the University-Industry Interface in *Science and Engineering Ethics*, 2009) but we must recognize it. We cannot be pretending it is an apolitical effort".

(xiii) Integration could then also be seen as a classroom/pedagogic negotiation between the 'life worlds' of students (which always already include values-desires-commitments-rationalities and within the web of which science learning happens) and what has contingently emerged in a given time-space as the domain of the 'political'.

Based on a critical reflection on all of the above we have arrived at our own justification for integration. We argue that integration means bringing into dialogue natural and human science knowledges/methodologies; such integration is to produce 'new and relevant' knowledge; it is to produce knowledge of a 'third' kind – knowledge that is neither exclusively natural nor human science knowledge.

(3) The Process of integration: The third area of research was an investigation into how to make such integration possible at science teaching institutes. What were the earlier experiments? How should the research-curriculum continuum be designed to ensure that the hitherto separate sciences are getting integrated? What are the institutional changes that will be required for integration? The connection between research and teaching and curriculum design based on relevance to UG science education is extremely crucial; introducing HSS courses with no connection to science education itself will have little relevance to the students obliged to take them. While on one hand faculty recruitment and infrastructure development is essential for the success of integration, the interest and feedback from the students would be another determining factor. Here the development of the researchers' collective on integrated themes is also vital – because such collectives would be the future harbingers of the integrated approach at science teaching institutes;

> such collectives would develop curriculum on integrated themes and also generate research interest in students on such themes. Raina et al of the Department of Education, Jawaharlal Nehru University, New Delhi have stated that the problem of science education and science curricula in India is 'bad pedagogy' (rather than just disciplinary segmentation once inherited and now inherent in the education system); they have also suggested that research and teaching will have to be connected and complementary; just like teaching a course on particle physics in a science institute without carrying out research on physics is not recommended, teaching a course on human science concerns in the same science institute without carrying out human science research is also not recommended; also, without integration of research questions/problems students are bound to miss out on the value such a human science course can provide to science education.

In this context of the *process* of integration, Andrew Stirling speaks of "a *dance between contending forces*. On one hand there is a strong motivation from within science and institutions, to acquire some greater legitimacy in a variety of ways for their activities, by appropriating social sciences and being able to say that they have taken another facet on board. However, the way they engage with social science and humanities is very instrumental; thus the agendas of science, the problems of science and the priorities of science are very much in the foreground whereas the humanities and social sciences come in around the edges to help them for instance, in public education, or acquire more acceptance of the things sciences are determining. On the other hand, among the social scientists and to a lesser extent in the humanities, the agenda is backed by the thought: we are interested in helping scientists and sometimes there is very

important work to be done in the public education profession and we can help but there is more to it than that. For they are at not at the end of the pipe, they are at the top of the pipe as well and can determine priorities and help to interpret what science can or cannot do at a very high level; these can lead to a dance or a conflict. This conflict can occur at many levels. Sometimes it can occur at the level of the individual curriculum, the individual lectures being given to science students by humanities academics. Sometimes, it also occurs in the design of the terms of the trade. The roadmap has to be measured by that dance of conflict. My advice is to be explicit from the beginning where you say that there are different ways of looking at a problem and both have its pros and cons. Thus there is an important role to be doing in supporting science and there's also one in making science more responsive to external priorities and interests and these things can't be reconciled. There has to be a dialogue about the role of power in science. That for me is the way to do it". Sterling's views are in dialogue with Leena Abraham's (*Associate Professor at the Centre for Studies in Sociology of Education, Tata Institute of Social Sciences (TISS), Mumbai)* views, who feels that with the growth of market, and the changing nature of capitalism and how science and technology have became powerful both materially and ideologically, even social sciences have began to kind of imitate natural sciences and its whole field of objectivity. This is only pushing the possibility of integration to a receding horizon; we are ending up with a mechano-morphic epistemology in both the natural and social sciences; both sciences are becoming domains of detached (or value and desire stripped) rationalities where 'nature' is 'natural resource' and the 'human' is 'human resource'.

Leena Abraham also distinguishes between two forms of integration – integration attempts coming from the natural science side (for example Medical Ethics/Sociology) and those coming

form the social science side (for example Ethics/Sociology of Medical Practice); which is why when one is trying to engage with the strong programme of integration one will have to keep in mind how the hierarchies of research perspectives are put in place; one will have to see whether it is from the perspective of Medical Sociology or from the perspective of Sociology of Medicine; the distinction albeit subtle is important.

Ravi Subramaniam (*Homi Bhabha Centre for Science Education (HBCSE))* feels that the main stream schooling system in a culture like ours is strongly influenced and shaped by a culture of competitiveness and this will affect attempts at integration: "This is very unfortunate, because what you get as a result of intense competition is a particular kind of student profile. I don't say a particular category of students but the students themselves are shaped to think this way. It is not something that is sustainable in the long run. Students coming from pure and sheer interest, and delight in these kind of activities, thinking and taking delight in that philosophical element of reflection, about reality, about the world, about particular aspects of reality that science deals with, and about the connections of those larger questions. Ultimately science research is driven by deep questions, even though you may be researching on a small thing, you may be studying what is the influence of some particular chemical on the emotional behavior of a rat, but questions at the back of your mind are how are … what are the forces which shape us, how do we understand ourselves. That's a deeply philosophical question. That drives our specific interest and it sustains and allows to make connections and to expand the whole. That's the source of creative urge. So you need that. *You cannot have a system where competition alone determines your entry into a research career*… that's very unfortunate. Of course we are trying to improve and refine those systems of competition. You need to think of other things, for example many

students are turned away by the competition; they are turned away by the narrow focus of what goes as scientific research. In fact we turned into other areas like journalism, or the social sciences or history or something like that which seems to be dealing with larger, more real issues of great import. A young student who looks at science as something which is narrowly focused and entry to which is largely governed by competitive culture is likely to be turned away. There are many bright students who possibly could contribute creatively. Of course there are many students who are excluded for other reasons, like social reasons. Of course we are a developing society with strong social strata, so many students do not have access to the kind of education that you need to participate in knowledge seeking. … I would say as a student as I became interested in humanities I lived through a certain tension, I lived two different worlds, in some sense schizoid existence, may be there is a way of not having these. I remember in the second year when my interests were developing I happened to watch the *ascent of man* series … and it was fascinating and I became deeply interested in mathematics and in the history of science at that time. But there was no opportunity to pursue those interests. What were available were core humanities courses because nothing connected the dual concerns. That might have allowed me to strengthen my interest in sciences also. Of course engineering is a different ball game, its not that I had no interest in engineering, I worked fairly well for one year in engineering; I like tinkering with things although it's not my main interest. However *the pull of science, the pull of things which are more intellectual, more philosophical, which makes you reflect deeply is much stronger*. It is something which I can't resist. This is something which was not present in science and mathematics departments in these institutions which were largely focused on engineering. Even the science departments were seen as 'tool departments', they were furnishing tools of science, whether its physics or chemistry or mathematics, it is basic tools you need to acquire in

order to learn engineering. I don't think they did justice to science or mathematics. When I read the Yashpal committee report in higher education it really struck a chord because *we our brightest students are working in campuses which offer really narrow avenues of knowledge. The challenge is very limited.* You have engineering, you don't have science or humanities; you don't have those broad university bases. We have lived in two different worlds for too long, we can't afford it. I completely agree with the spirit of Yashpal committee's report though operationalizing it in our culture is going to take a long time; it's not going to be easy. … To me *education is also a process of socialization*. It's not merely preparing a student in terms of knowledge and tools. … I am really impressed with the social sciences because they maintain some connection with social movements. … *The more I work on education the more I realize it's a complex domain for reflection and for practice. Its quite often a balancing of things, you cannot afford to swing too much in one direction,* the pendulum cannot swing too much in one direction. Since it is complex one must keep many perspectives in mind. One must understand that the students who come to the institutions come from a particular culture, history, time frame, practice, have a particular personality, background, value, interest, commitment, desire and the education system needs to be sure to keep these in mind and keep a balance between various aspects and see to it that it does not swing too much in one direction". One again, like Rath, Subramaniam

Asha Achuthan has suggested that integration is also about *interruption*. It is about translation across incommensurable barriers and hence not easy: "We tend to think that translation can happen only where there are commonalities. But translation can happen across incommensurable paradigms. Translation is required where there are paradigms that seem incompatible. Part of the

reason why social scientists will deny being a part of their discipline is because when they started with a critique of science and did a thorough and objective enquiry into the science they find that the critique was wrong. So what is the basis of critique then? Because social science has certain theories of exclusion… the hegemonic for instance. We are critiquing dominant frames and we don't have any idea about what we mean by the hegemonic and we don't have clear theories of exclusion. These may sound like tall orders but one needs to have them nevertheless. One needs to clarify what you mean and then to communicate this. *The value of science has been that it has forced you to clarify what you are saying. That engagement has made a lot of social scientists look back on the methodology of their critique* at least that is what happened to me. So placed in a pure research institution and having some form of the conspiracy theory of science all helped me when I reflected on them. I recognized that I was doing something wrong that even though I was trained to say, detect androcentrism, I wasn't really doing it. I realized I had to let go where I was doing things wrong. … Also, the most vital activity of interdisciplinarity is within the discipline. … I think integration has more of a sense of activity – institutional activity than interdisciplinarity. Interdisciplinarity is more a reflexive form of activity within a discipline. Integration has been around for a long time. It may not have been under this label. From the time Higher Education began, since the idea of good citizens came up. My question is if we can make interdisciplinarity the basis for integration? The kind of interdisciplinarity I am talking about – use that as the basis for integration. First of all there won't be a collapsing of disciplines; one will not speak about defection from disciplines. It is not useful anymore to talk about interdisciplinarity like this". Achuthan has thus raised three important points for integration efforts: (a) Integration has as much value for the social sciences as for the natural sciences; speaking or translation across incommensurable domains help both the sciences, in terms of

generating 'reflective clarity', (b) The most vital activity of interdisciplinarity is at the core of the discipline and not at the margin and (c) One needs to make such interdisciplinarity the basis of integration in the contemporary.

INTEGRATION ATTEMPTS IN COMPARATIVE PERSPECTIVE

There have been several attempts in India (and abroad) to address the above mentioned concerns/problems. One therefore needs to take stock of earlier attempts and then mark clearly the continuities and the differences the model being suggested by the ISE initiative has with the earlier attempts/models.

Raina et al have shown that the history of science in post-colonial India could be mapped into three broad periods:

(i) the *golden age of scientism* spanning the Nehruvian decades that began to wane in the 1970s,

(ii) the *decades of disenchantment* with science that extend into the early 1990s, and finally

(iii) the *decades of the rise of neoliberal science* in which we are still located where questions of 'knowledge economy' have become central (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 suggested ways of overcoming the limitations of bad pedagogy, equally while addressing some of the larger issues of science and society. 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.

The Kothari Commission Report (1965), which was a landmark report in the history of science education in postcolonial India, suggested that science education was just not about imparting knowledge of the theories and techniques of science. On the contrary, at the UG level, a different role for science was envisioned by the Committee: in the context of liberal education, science, insofar as it had the potential of serving as an exemplar of analysis and the so called scientific method itself, was seen as 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).

Raina et al thereafter differentiates between two institutional structures wherein the engagement between science and society in curricula was motivated by different sets of concerns and seeded by different kinds of programmes. The first discusses the programmes developed within the university system from the 1960s onwards, and the second discusses the programme 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 was 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".

1. The Approach of the University System

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 (DU): "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 (a book authored by Hariharan was used as a reference book by 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 course itself was a disaster, the Delhi University physics department kept a kind of reflexive engagement with the subject 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). HSTP was the first attempt in India to set up a school science teaching programme on an altogether different foundation. Much later those associated with this experiment in association with other physics teacher's inaugurated the *Centre for Science Education* in Delhi University. Attempts were undertaken in the 1990s to reformulate the 1965 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:

(i) The History of Scientific Ideas – This was already present in the earlier course. The other components were new and reflected the growing concerns of the times. These included:

(ii) Science as a knowledge system

(iii) The Social Setting of Science

(iv) 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. The rather non-standard arguments made by enlightened scientists to justify a course on "science and society" make sense within a conception of the liberal university culture of democratic citizenship: "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 departments. The first thing observed on approaching the Arts space 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". Amitava Mukherjee feels that the science and society course should be offered not just to science students at the university but to all the students at the appropriate level. 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 attempted to engage not only with a new science curricula but to equally push forward their reflective and social concerns about science and society that need to find an echo in a

liberal undergraduate education. Within the Centre a short term course had been proposed on *science communication*. However, it was not yet clear whether such a course should 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 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.

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 that 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. 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 and the Birla Institute of Technology and Science, Pilani did not 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*. 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:

(a) There was *no specialised teaching faculty* to teach the course (the Strategy Paper would therefore like to argue that one needs to train scientists in these areas: Teacher Training would need to be one step to integration).

(b) The *paucity of teaching material* at the student level was the second factor (the Strategy Paper would therefore like to argue that one needs new material to teach students in these areas: Materials Production would need to be other step to integration). 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.

(c) And finally, there was no question bank, standard examples and questions which constitute the culture of Indian university examinations.

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 the two major cultures that divided 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.

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 *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.

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. 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, 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. 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.

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. 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 enroll in other courses offered by the university or found an appropriate vocational opening that was more satisfying.

2. The Approach of the Elite Institutes of Technology

Outside the university system, the attempts to get courses on "science and society" rolling reveal a greater degree of success than in the university system. There are several important organizational features of the "institutes of technology" that enabled this relative success – 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 one needed to assess their position within these centres of technological education.

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.

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. P.R.K. Rao reminisces that in the 1970s and 1980s Humanities and Social Sciences was seen as a necessary evil. In fact, the idea 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, 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 transforming and re-engineering Indian society. 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 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 to 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 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. 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 philosophy of science from IIT-K. 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 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. His commitment to the field has been such that while at the IIT-K he even translated Kuhn's *The Structure of Scientific Revolution* into Hindi.

.

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. Raina et al have 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*. Further, 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*. This 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 is important to note that a course such as this will only serve a limited objective as does a liberal education.

Indian Institute of Technology, Delhi

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. 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 Basu 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 the Central University of Hyderabad, Basu felt that he organized the courses in order to *get students to think about problems qualitatively*. 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". Or how do we decide what is ours? In other words Basu'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 *instill 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 an appliance, or 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 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.

Rukmini Bhaya Nair, has been teaching a course on *technology and culture* to undergraduate students. 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). Nair feels that the book was considered unreadable by 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, Nair 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 Nair has experimented with the production of an SMS novel. The underlying hypothesis was that almost every technological revolution produces a new literary genre. 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. Nair sees the IIT student as sacrificial victims at the altar of modernity. According to her any conception of liberal education has a notion of an in-built relativism or of other alternatives. Further it also involves pursuits that are not necessarily part of a vocational apprenticeship. In other words, there is a tendency amongst 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 punishment in the IIT context according to Nair 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 skepticism 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.

Sanil V. teaches courses on *art and technology, philosophy and film, and 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. 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. However , 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.

In the process of preparing the Strategy Paper the ISE initiative spoke to a number of scientists 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 a wider culture or do we wish to instill 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"? Taking off from their interactions with extant or present IIT faculty, Raina et al, in their report have opened a few windows: (a) Prajit Basu suggested that one of the ways to address 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. (b) Rukmini Bhaiya Nair felt that within the IITs the examination system is an instrument for disciplining the IIT-ian even though there are 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. (c) Sanil V. felt that 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. Sanil feels that just now it is the PG programme that needs a bolster. 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 one is witnessing what Raina et al have called the onset of 'Mode-2 of Knowledge Production'[4].

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 History of Science, Contemporary Philosophy of Science, Science and Technology Education, Studies in Technology and Society, Perspective in Science Education, Philosophy of Technology and Science, Technology and Society Studies.

[4] "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. 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. 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 and University centered 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" (Raina et al, 2009).

The above stock-taking of past and existing courses through excerpts from Raina et al's report and through the ISE initiative's own review of courses have helped us arrive at what we would like to call the three given models of integration. These are:

> *The Model of HSS at IITS* ('innocuous insiders'): The first, prevalent in India, in particular the IITs, was the model of setting up Humanities and Social Science (HSS) departments in science/technology institutions. Nonetheless, a critical analysis of the model shows that these HSS units were not integrated into science institutions; as 'innocuous insiders' HSS units have merely been 'service' departments of science/technology institutions who give to science students, at worst, an awareness of social issues and at best, a dose of social science information. While HSS units were not able to give science-technology students a thorough knowledge of human science methodology; they did not incubate the production of 'new' knowledge based on the dialogue/integration of natural and human/social sciences. Students of technology could not relate to the courses that were offered in HSS units. The relevance quotient of such courses in the milieu of the teaching of technology was low. The lone student who took such courses seriously and moved to foundational questions (like what is science/technology in light of the history and philosophy of science) soon found himself/herself orphaned or marginalized in the context of the general trend of the institution primarily, because there was no institutional support/room for the housing of such interface questions – questions located at the interface of natural and human science.

The Model of Critiques of Science ('critical outsiders'): The second was the model of the 'critique of science' in existing HSS departments in universities. Here history, philosophy and sociology departments in universities playing the role of 'critical outsiders' examined the knowledge of science without engaging closely with the practice of science or with practicing scientists. While science education and research requires being critical and self-reflective, this critique of science coming from the outside is in itself problematic for it does not make possible the germination of new knowledge in the sciences; it instead produces resistance to such critiques among natural science students.

The Model of Interdisciplinarity (as 'add-on'): The third is the model of interdisciplinarity of an add-on kind; interdisciplinarity as against cubicalization has been posed as a strategy to deal with the problem of the separation of natural and human sciences. However, Raina et al have suggested that the formula for developing successful interdisciplinary fields has not challenged the underlying epistemologies and methodologies of the constitutive disciplines. At times interdisciplinarity becomes an add-on of secure disciplines. When the boundaries and frameworks of respective disciplines are not porous; it becomes a marriage of convenience between disciplines.

Given the above three, the Strategy Paper would propose 'integration' as another solution to the problem of separation-insulation. Integration calls for shared attention on objects of enquiry; this leads to both conflict and collaboration between disciplines; it leads to an assertion of the distinctness of a methodology (the privileged perspective it produces) as also dialogue between methodologies; it leads to a critical reflection on respective disciplines/methodologies as also an

understanding of other/alien/contra disciplines/methodologies; it leads to an opening up and displacement of the hitherto separated/cubicalized/secure domains of knowledge. In the process an integrated third (methodology/perspective) is produced – a third transcending the two of natural/human science – a third haunted by both 'stable horizons of sharing' and 'momentary eruptions of contradiction'. This integrated third is the ground and condition for 'new objects of enquiry' and 'new problems' – in a nutshell, 'new science'.

Thus through integration, we hope to challenge "underlying epistemologies and methodologies of the constitutive disciplines" and develop in the process a third kind of methodology that will not be restricted to what has come to be known as natural science and human science methodologies. We would thus like to mark our contention with the interdisciplinarity model, since integrated science education is premised on the perception that integrated ways of dealing with the complex problems of reality would need to be found. And this cannot take the form of the model prevalent in the IITs or the interdisciplinarity model.

Taking off from the above insights, we are therefore proposing a *dual model* for science teaching institutes. Through the soft programme of integrated science education we would like to offer students courses in history and philosophy of science-technology or on the science-technology-society-industry-policy interface. This would be to orient students towards contemporary global concerns as also with the way science has been and is being done in India and the world today. However, we are also suggesting a strong programme for institutes which are concerned solely with science education and research and cannot parallel the open-ended university model that offers its students a choice from a menu of a wide variety of courses. The strong programme will

focus on those areas where natural and human worlds need to meet and pilot integrated themes of research and teaching around these areas. Some of the integrated themes that are of immediate relevance to UG spaces are for example (a) Cognition (along with Mental Health as its clinical or application oriented interface), (b) Environment, Bio-Diversity and Climate Change (along with Habitat, Sustainability and Livelihoods related concerns), (c) Energy Issues (along with questions of Industrialisation, Development and Globalization), and (d) Bio-Technology and Bio-Ethics (along with questions of cloning, organ transplantation and health).

Integrated science education could thus be one attempt at striking at the root of the lacunae and problem besetting science education in India today; as also bridging the 'two cultures'.

SUMMARY: The ISE initiative reviewed extant models of integration so as to arrive at its own model:

1. The existing model of setting up HSS units in the IITs lacks in its relevance to the science-technology education that is incumbent in IITs. One needs to introduce human sciences in relation to what was being taught in science-technology spaces and not in isolation. One also needed to engage with the life worlds of the students.

2. Critiques of science are seen with suspicion by natural science students; critiques, if at all, need to be located in the context of reflections on the historical moorings and philosophical foundations of science-technology.

3. Interdisciplinarity of an add-on kind where disciplinary boundaries and methodologies are not challenged is a small step towards integration. One needs to take a leap in terms

of interrupting existing disciplines/methodologies so as to produce integrated knowledge – knowledge that is neither exclusively natural nor human science. Such knowledge would 'render known' existing objects/areas of enquiry in a new way or give rise to altogether new objects/areas of enquiry.

4. We therefore recommend the implementation of an altogether new model represented in terms of the generation of integrated research themes – themes that presently require both natural and human science inputs and that beg the development of a new methodology – a methodology transcending given natural and human science methodologies. The few themes of research and teaching that could be developed in the coming years are

    (1) *Environment*: Connecting Natural and Human Histories

    (2) *Cognition*: Beyond the Mind-Body Divide

    (3) *Energy*: Relating Nature-Human-Technology and

    (4) *Bioethics*: Bridging Values, Desires, Commitments and Rationalities.

    However, so as to not to throw out the baby with the bathwater, one should retain in a somewhat displaced form two of the earlier attempts at integration through research and teaching in (3) History and Philosophy of Science-Technology (HPST) and (4) Science-Technology-Society-Industry-Policy Studies (STSS); both HPST and STSS should take note of the Indian context and the concerns-questions-issues of the contemporary – in terms of both global changes and internal changes within science-technology research.

Bibliography

Anderson, Robert S. 1975. Building Scientific Institutions in India: Saha and Bhabha, Occasional Paper Series No. 11, Centre for Developing Area Studies, Mc-Gill University, Montreal.

Banerjee, D. 1996. "25 Years of JNU: Betrayal after a Promising Start", in Kanjiv Lochan (Ed.), JNU: The Years, An Anthology by the Silver Memoir Committee, Popular Prakashan.

Bhaya Nair, Rukmini (with Ramnik Bajaj and Ankur Meattle). 1997. *Technobrat: Culture in a Cybernetic Classroom*, Harper Collins: New Delhi.

Luhmann, Niklas. 1982. *The Differentiation of Society*, New York: Columbia University Press.

Nanda, Meera. 2004. *Prophets Facing Backwards: Postmodernism, Science and Hindu Nationalism*, Permanent Black.

Nowotny, Helga and Scott, Peter and Gibbons, Michael. 2001. *Rethinking Science: Knowledge and the Public in the Age of Uncertainty*, London:Polity Press.

Open the Social Sciences: Report of the Gulbenkian Commission on the Restructuring of the Social Sciences. 1996, Stanford University Press.

Raina, Dhruv and Sivaramakrishnan P. Manikonda. 2006. "Challenges for Science Education", *Seminar*, 565, pp. 47-51.

Raina, Dhruv. 2003. *Images and Contexts: The Historiography of Science and Modernity*, Oxford University Press: Delhi.

Raina, Dhruv. 2007. "Science since Independence", in Ira Pande (Ed.), *India 60: Towards a New Paradigm*, Harper Collins India, pp. 182-195.

Readings, Bill. 1996. *The University in Ruins*, Harvard University Press.

Snow, C.P. 1969. *The Cultures and the Scientific Revolution*, Cambridge University Press.

Visvanathan, Shiv.1997. *A Carnival for Science: Essays on Science, Technology and Development*, Oxford University Press.

SECTION III

Integrated Courses: India and The World

As the initiative sees it, integrated courses in science education have taken one of two paths (See Appendix for list of integrated courses in India and Abroad).

1. Integration that occurs *within* the (natural) sciences. In this instance the integration occurs across disciplines still considered within the ambit of the natural sciences: Nanotechnology, microbiology, Biochemistry etc. These have often spawned into disciplines of their own sometimes losing their interdisciplinary character that is, of breaking down traditional barriers between disciplines.

2. Integration that occurs *between* the social and natural sciences. Some may consider this to be 'true' integration; History and Philosophy of Sciences, Environment Studies, Culture and Cognition as just a few of the examples of these courses.

This section of the strategy paper examines the current set of integrated courses in India and the world:

Integrated Courses in India

While it seems that integrated courses in India focus more on the integration that occurs within the natural science there are several institutions that are also focusing on the latter category. These take the form of short term courses while also offering courses with larger programmes. The Indian Institute of Technology, Delhi for instance offers an interdisciplinary M. Tech in the

following: Computer Applications, Energy Studies, Energy and Environment Management, Industrial Tribology & Maintenance Engineering and more. While the Indian Institute of Technology seems to offer inter disciplinary courses well within the ambit of technology there are other institutions that focus on more interdisciplinary areas like Science Technology and Society for instance.

Science-technology-society-studies refer to the study of how social, political, and cultural values affect scientific research and technological innovation, and how these in turn affect society, politics, and culture. STS scholars are interested in a variety of problems including the relationships between scientific and technological innovations and society, and the directions and risks of science and technology.

Courses offered in India tend to be restricted to the Masters and Ph D level. Some courses have been combined with other areas like environment. For instance the M.A./M.Sc. in Habitat Policy and Practice programme (MHPP) in **IITB-TISS School of Habitat Studies** is multi layered. This course has combined concerns with the habitat (environment) along with science-technology-society questions specifically with respect to **policy**. The MHPP programme will teach students to ‘find appropriate types of solutions for specific niches and help to adapt these to particular situations’ The current concentration areas include frontier areas such as ‘urban responses to climate change’, ‘water sector regulation’, and ‘affordable housing for poor’. Students will be ready to work as **Urban Policy Specialists** and will be able to work in diverse capacities to *design and formulate policies, manage and monitor implementation of the policies*

as well as programmes and projects based on the policies, conduct research and analysis of policies and programmes, and, finally, undertake advocacy activities on policy matters.

Other Institutions like **NIAS** conduct specific short term courses/ workshops for certain target groups. (i) **NIAS-DST Training Programme for Senior Scientist-Administrators** is one such example. This course (1 week) is directed towards a group of **senior scientists** and organized by DST and NIAS. The *purpose of the course is to provide scientific, social, economic and cultural perspectives on the science and technology enterprise in the country.* (ii) '**Dimensions of Nano-Technology: Science, Technology, Business and Society**' is an ongoing workshop conducted in conjecture with the Indian Institute of Science and Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR). Nanotechnology is making enormous changes across the world in the past decade. It is often hailed as the second industrial revolution and is termed as disruptive technology. It also has the power to transform society particularly in India.

(iii)**Course for Indian Foreign Service Probationers**

This course is of a one-week duration. The thrust is to provide the probationer diplomat with a *broad outlook on India's cultural, economic, social and intellectual ethos, including in particular science and technology, to enable deeper appreciation of the issues peculiar to a transforming civilization that is building new relations with the rest of the world.* Four courses have been conducted so far.

Center for studies in science policy (School of Social Sciences): M.Phil/Phd in Science and Technology in Social Context. It focuses on the main perspectives in Sociology of Science, covering leading contributions in the field from the 1940s to the contemporary phase of globalisation. The course will relate these perspectives to understand and engage with developments in

contemporary society. The second part covers the theme on Technology and Society. Here the focus is laid on three main perspectives, *namely, social shaping of technology, large technological systems and networks.* The third part deals with Social History of Science and Technology in the Indian context. Main themes, which will be covered in this part, are *colonial and postcolonial social history of science & technology, emergence of Indian science community and post-independence developments covering the role of scientific and political elite.*

The Indian Institute of Science Delhi is an exception which has as part of its undergraduate course a component on STSS which is offered by the HSS department in the institute.

STSS Research Workshop at CSSP, JNU: this was a workshop that occurred in 2004 that is worth mentioning for the broad range of topics covered. (it is also indicative of how broad STSS has become) The sessions were broadly grouped into four main groups. These respective frameworks were grouped under : **a)** Sociology of Science and Technology, **b)** Science and Technology Policy Studies **c)** Social History of Science , **d)** Historical and Sociological Studies of Science. And example of the topics covered is: *Diffusion of medical technology in India and its attendant impacts for public health.* The argument was that by plotting how the rapid growth in medical equipment technologies in India had ironically led to a rapid erosion of popular access to both medicine and healthcare amongst the people at large. Others' presentations centered on history. *On emergence of science and scientists in late colonial India, and how ultimately began to influence and shape the project on nation building in India.*

STSS in India seem to focus on issues of policy making (especially within the urban context: issues touched upon include electricity, water, housing), public health. There are some courses that dedicate components to understanding science and technology as born from a social context.

These components are pedagogic in nature and research oriented. The thrust of some courses in India when it comes to STSS is to develop professionals. These have focused on practical applications and field work as major components.

Another area that garners a lot of attention is the area of **cognitive sciences**. Again, quite like STSS these courses are limited to the post graduate and beyond. **The Centre of Behavioral and Cognitive Sciences (CBCS) in the University of Allahabad** offers both a Masters and PhD programme. Research areas in CBCS include Perception, Attention, Emotions, Consciousness, Creativity, Decision Making, Social Cognition, Language processing, Learning Disabilities and Cognitive Development. According to the Centre it is the only one which offers a Masters in Cognitive Sciences in the country. The course features papers from the realms of Philosophy Lingustics and mathematics. Others like **Jadhavpur University offers an M.Phil** in Cognitive Sciences from its Centre of the same name.

Indian Institute of Bombay offers a doctoral programme where it is possible to do inter disciplinary work across the natural and human/social sciences. The research areas span across English, History, and Psychology.

The International scenario:

In the international sphere integration has existed for a long time and the courses reflect these changes. While there are courses that are specifically designed for students to help students enter the workforce whether courses on Biotechnology and Microbiology there are enough number of courses which focus on the philosophical mornings of a discipline. An instance of this,

Princeton University has set up an integrated science programme for its students. Its website promotes the programme offering incentives like the integrated Science students get to talk science one-on-one with the best-of-the-best Princeton faculty: the current roster of active teachers includes members of the National Academy of Science and a Nobel laureate. Most institutions are going out of their way towards promoting integration in a big way in their institutions by offering additional incentives. Aware that these courses do not have as much currency as non integrated courses, there is a move by these institutions to sell these courses as not only a viable option but a beneficial one. This encouragement remains exclusive to integrated courses within the natural sciences.

Outside of the institution, there have been efforts in Europe to bring the social sciences into the fold by making changes at the level of policy. For example, setting a target of allocating 5% of the overall research budget to the SS&H over the next 10 years or so is one such example. Such a commitment of resources would act as a considerable incentive to mobilise the SSH community (national funding bodies, National Academies, European research networks and researchers) to collaborate in European scale research projects.

In some countries Science Technology and Society undergoes a philosophical transformation where quite literally the course designed is named Philosophy of Science Technology and Society. The course is a Masters level one offered at the **University of Twente.** Here too there is an attempt to pitch the course. The site promises that engaging with such a course will open a student to many career possibilitites, “including positions in government and policy, academic and R&D research, teaching and consultancy.” The course offers papers in Philosophy, History Ethics and Technology.

In the international scene there are a number of institutions offering history and philosophy of science yet some have found ways to make changes and renew the course. In the **University of Exeter** for instance, students have the option of doing an M A in Philosophy and Sociology of Science which examines the concept of science from both historical and sociological perspectives. The students have also been given the opportunity to collaborate with ESRC Centre for Genomics in Society (Egenis) – a recently established research centre at Exeter set up to investigate the meaning and social implications of contemporary genomic science. Therefore one can see that far from throwing the baby out of the bathwater institutions are finding ways of keeping some of these courses alive and relevant.

In summary integrated courses in India and abroad offer similar combinations from across disciplines. There are still many institutions offering History and Philosophy of Scinece and while we do argue that this is perhaps not creating new areas of research its existence is vital as indicated by its mere presence. What is also clear is that integration is not being offered before the post gradutate level. This is a shame as the numbers of students who go on to do their post graduation and/or their PhD's are few and far between. The ISE initiative suggests that more integrated courses be offered at the undergraduate level spawning interest and drive to continue further into higher education.

SECTION IV

Note:

The Integrated Science Education Initiative of the HE Cell would like it to be noted that the following interviews are still in the process of being written/edited by the interviewees. It requests all not to reproduce/quote or reveal the contents of these interviews before they are formally published.

DR. ANDREW STIRLING

JANUARY 25, 2010

Andrew Stirling's early academic background is in natural science, followed by a Masters in Archaeology and Social Anthropology (Edinburgh, 1984) and a doctorate in science and technology policy (Sussex, 1995). Working as a field archaeologist and environment and peace activist in the 1980's, he later co-ordinated nuclear, disarmament and energy campaigns for Greenpeace International in Amsterdam, serving on their Board of Directors in the 1990's. Alongside real life, he now works as an interdisciplinary, policy-engaged researcher, trying to focus on challenges of empowerment, environment and human wellbeing in the governance of science technology and innovation.

Recent Publications include:

1. A. Stirling, Risk, Uncertainty and Power, *Seminar*, **597**, 33-39, May 2009

2. A. Stirling, Multicriteria Diversity Analysis: a novel heuristic framework for appraising energy portfolios, *Energy Policy*, forthcoming

3. A. Stirling, Science, Precaution and the Politics of Technological Risk: converging implications in evolutionary and social scientific perspectives, *Annals of the New York Academy of Sciences*, **1128**, 95-110, April 2008

The Initiative: What is your experience with integrated questions concerning for instance, connecting science with technology, connecting science and technology with policy questions and also with larger social and cultural questions?

Dr. Andrew Stirling: My interest/issue (at least within the European setting) lies in the tendency to treat questions of innovation and knowledge as if power were absent. Therefore there is a tendency to be either very deterministic; where there is only one possible way to treat questions-as determined by nature and only which experts can identify. Though there may be powerful forces towards technocracy, when it comes to science-technology question and integration, this trend is especially pronounced. Though quantitative methods are criticized for doing this- providing one single answer; the qualitative methods partake in this as well. Social sciences think they are immune to it but they are not. For instance even in using a deliberative process of enquiry (with participation) there is still a tendency to close down decisions and come to a single answer when there can be many different possible answers.

The Initiative: In India, science is deterministic and myopic in its training and teaching often studying what is fashionable, and ignoring other contexts and approaches. What is the experience in the United Kingdom- specifically with respect to science teaching and learning?

Dr. Andrew Stirling: Science teaching (today) includes more debate on the social context of science as well as an increased readiness towards inter disciplinarity. There is still a tendency to treat inter-disciplinarity as multi-disciplinarity where each discipline has its own divided area where it will be acknowledged but the terms of trade between the disciplines are set a higher level usually, by the dominant discipline. Real inter-disciplinarity however is when the terms of trade between disciplines being settled by the disciplines themselves in a more symmetrical fashion. So that they interact on terms they can decide on. What is really lacking in science education is trans-disciplinarity. My definition of tran- disciplinarity is where not only do the disciplines deal with each other on an integrated and symmetrical basis but also the problems are set outside science, so science is responding to questions of stake holders outside science.

The Initiative: So taking off from what you have said, if science students are now getting exposed to these broader questions, how are they getting exposed? What are the structural changes occurring to cause this exposure? What would you posit as change between the 80's and the present?

Dr. Andrew Stirling: My impression is that the pressure exerted by recruitment is responsible. For instance, Science universities are finding it difficult to recruit scientists. Among many strategies, they are forced into trying to make scientists more appealing. In order to make them more appealing they address more inter-disciplinary problems through for instance, Environmental Science and science related to industry. These days there are more courses around that are paying attention to inter disciplinarity. It also motivates students as it addresses social problems, environmental problems or because it makes them more recruitable into industry because they have looked into economics and finances as well. The Universities are too captured by disciplinary interests and this is being forced into the science area where the push is to be more open minded.

The Initiative: So would you say that (now) there are questions/ challenges being thrown up at science education from its contemporaries? Also, that these questions are coming from the industry and the community at large?

Dr. Andrew Stirling: I would say that science education left to its own devices is still very subject to disciplinary boundaries within the University. That is being forced by these pressures for recruitment. In Europe there is a real issue when it comes to recruiting students for the sciences as they want to go study other subjects. The science departments in Universities are being forced to be more open minded about the way science is applied and taught. More importantly, science in Europe sees itself as under siege by critical social forces. The issues usually center on the forces that control science, where does money go, what types of problems it addresses and in particular, public engagement. All these are matters relating to the control and governance of science. However from within science the response to pressure for public engagement is to devolve responsibility to the least powerful people in science- the individual scientist. There is a tendency by the powerful scientific institutions and bodies like the Royal

Society and various Research Councils, to externalize the pressure to be more accountable onto the individual scientist. Therefore it adds another dimension to science education. Increasingly public engagement, talking to people, science communication, is being seen as part of a scientist's curriculum. Therefore individual scientists are being disproportionately burdened by a responsibility that should be the responsibility of the high state institutions.

The Initiative: As a Professor of Science and Technology Policy Research, what is the kind of work you do?

Dr. Andrew Stirling: We are unusual in that we are largely a contract research institute. We have 40 people who work on science technology and policy on a research contract basis. The areas we look at scientific uncertainty, the governance of innovation, public participation.

The Initiative: We have noticed that in a lot of European documents there is a strong foreground for "risk". Is "risk" then, a central question in your work?

Dr. Andrew Stirling: I tend to approach risk through the term uncertainty. Part of my analysis of the word "risk" is that the very word narrows down or tries to treat a problem as something that can be resolved by quantification or by probabilistic analysis. My concern is that a lot of it is not tractable to quantification so we should call it uncertainty. There was an attempt to discuss it in the Indian Journal Seminar.

The Initiative: How would you mark your research with respect to earlier studies relating to science- technology society? What are the continuities and discontinuities you can see?

Dr. Andrew Stirling: The tradition I am working in, is at the interface between two big different approaches. One is the constructivist tradition where you have leading figures like Sheila Jasanoff. The other one is the positivist tradition looking at science policy and innovation where there are people like Economist Chris Freeman and. I am really more in the tradition of Sheila Jasanoff. I am interested in engaging with policy making in a way that's quite direct and producing tools that have the effect of conveying. I always use the analogy of the Trojan horse. It

looked inoffensive so it went through the gates. I try to develop tools, whether thinking about uncertainty or appraising technology which looks inoffensive so they go through the gate of the technocratic fortress and only when they get in are they appreciated because they open things up in a more extensive way. The constructivist tradition isn't so interested in creating practical tools whereas I am.

The Initiative: Interestingly, some of your work uses Environment as a trope to foreground some of the questions. You also seem to have used energy questions are a conduit to foreground some questions. Can you comment?

Dr. Andrew Stirling: I am genuinely interested in and committed to issues of energy and on environment so I see them as more than tropes or conduits. In fact, in a way, it is almost the other way around. It is through seeking to address these issues I have sought to draw on and develop ideas in science and technology policy and science studies. Therefore the engagements come first and the attempt to address the conceptual and theoretical issues comes later.

The Initiative: A practical question- The IISER is a new science institute in India and seven more are coming up. IISER has a mandate from the government to include social sciences in their curriculum. Therefore they approached us (Center for Study of Culture and Society is a human science center) to include a humanities social science component. What would be your suggestion regarding bringing to science students, a humanities or social science component that will enable science education and knowledge production as well as science's relation with larger social questions, or even natural history questions?

Dr. Andrew Stirling: The background to this entire experience for me is that it's always a dance between contending forces. Thus on one hand there is a strong motivation from within science and institutions like the one you are talking about, to acquire some greater legitimacy in a variety of ways- for their activities, by appropriating social sciences and being able to say that they have taken another facet on board. However, the way they engage with social science and humanities

is very instrumental thus the agendas of science, the problems of science and the priorities of science are very much in the foreground whereas the humanities and social sciences come in around the edges to help them for instance, in public education, acquire more acceptance of the things sciences are determining should happen. On the other hand, among the social scientists and to a lesser extent in the humanities, the agenda is backed by the thought-we are interested in helping scientists and sometimes there is very important work to be done in the public education profession and we can help but there is more to it than that. For they are at not at the end of the pipe they are at the top of the pipe as well and determining priorities and helping to interpret what science can or cannot do at a very high level- these can lead to a dance or a conflict. This conflict can occur at many levels. Sometimes it can occur at the level of the individual curriculum, the individual lectures being given to science students by a humanities academic. Sometimes, it also occurs in the design in the terms of trade between the science institution and your center. Your message has to be measured by that dance of conflict. My advice is to be explicit from the beginning where you say that there are different ways of looking at a problem and both have its pros and cons. Thus there is an important role to be doing in supporting science and there's also one in making science more responsive to external priorities and interests and these things can't be reconciled. There has to be a dialogue about the role of power in science. That for me is the way to do it.

The Initiative: Where would you place the knowledge-society argument within this whole debate?

Dr. Andrew Stirling: From my experience, the Indian debate on this seems to be more sophisticated than what is happening in Europe. The debate in Europe is very pronounced even though it is considered a less fashionable subject in comparison to three years ago. In Europe the knowledge society-or the knowledge economy as it is often called, is actually at the center of the European project. The project for European integration (the big treaties, the new stage of unification between European countries) is organizing around science and technology and innovation. So Europe needs to be ready for this new phase in world history where events are driven by science and innovation and we need to be more effective because we are losing ground

to India, China as well as the United States in these areas. Therefore it's not just issues of power and innovation in technology and science; it's also a very big stake for the European project.

The Initiative: How do we reconcile environmental well being and human well being in the governance of science and technology?

Dr. Andrew Stirling: Governance is a very convenient term. It is often used to exclude politics. Instead of speaking of the role of the government we speak of governance systems. Thus there is a tendency in European contexts to speak of governance to be quite managerial. This is not just in science and technology but generally, it comes in when the objectives and values are self evident and the challenge is governance so as to best realize these objectives and values. Quite often though, the objectives and values themselves are at stake. Within science there are discussions around decision making in science and priority setting, which is quite technical but it also has political dimensions. If one refers to that as governance then it is a way of thinking more broadly about the political dimensions. For me governance is a bridging term, between these two those two ways of looking at things. It's already being used for instrumental reasons. But it can be used another way around where one looks at the political questions in science and how they are being handled. It can be used to draw attention to those kinds of issues. Governance can be very network like and because of this it is hard to see where accountability lies. Thus there is a network of actors all relating to one another in complex ways without any clear lines of accountability.

The Initiative: How do the science institutions or researchers who are involved with natural science react when you bring questions about sustainability, energy food, or bio technology? Also, as you do not follow a deterministic argument but a knowledge argument, how do they look at your work?

Dr. Andrew Stirling: It is difficult to generalize because there is so much diversity at the individual and institutional level. Reponses also vary according to the issue. Sometimes when there is a crisis like the one that occurred in Europe on genetically modified foods the political crisis opens up the issue for a couple of years. Institutions that were closed therefore become

desperate and start opening up to other voices. It is now closing down. With scientists working in policy processes there is a tendency to understand the issues at a personal level. But quite often they will not act on them or even express those issues. Informally, on the edges of a meeting they may agree. But in a committee meeting, or when it comes to decision making they will adopt a different point of view. So there is a difference in informal and formal domains for a lot of senior scientists working in the policy areas.

The Initiative: Would you convert these to curriculum?

Dr. Andrew Stirling: Over here we have a master's programme. It's easier in a master's programme. The programme is quite dedicated. The students only learn issues about science and technology policy or innovation management. Our research has a curricular expression for the post graduate students but we don't teach scientists in science courses.

The Initiative: Is it possible to curriculairze the type of research you and your team does for the undergraduate science student?

Dr. Andrew Stirling: I think it is. Some universities do it to some extent. They offer option to scientists. So you get only interested ones. They do courses on science and society and innovation. It is possible and can be rewarding. But there are questions about making everyone do it. It's usually the most motivated students who engage quite strongly and have very advanced ideas. The least motivated students however, don't understand it. Like I had mentioned earlier, there is a dance and they get stuck in the first steps of the dance. Therefore, the choice to be made is on whether it should be voluntary or compulsory. According to me, some kind of insistence on a compulsory element in the early years will introduce people to the existence of these issues in a very basic way. And then follow up in the later years for those science students who still wish to pursue their interest in natural science subjects but they've got motivation to think about society and some deeper issues then for them to have it in an optional element will seem to be the best way.

INTERVIEW WITH DR. SATYAJIT RATH

January 4, 2010

Dr Satyajith Rath's basic and post-graduate medical training was at the universities of Pune and Mumbai in India. His post-doctoral work was at the Haffkine Institute, Mumbai, India, London School of Hygiene and Tropical Medicine, London, UK, Brandeis University, Waltham, USA, and Yale University School of Medicine, New Haven, USA.)

Recent original publications (over the past five years)

1. Raman VS Akondy RS Rath S Bal V George A (2003) Ligation of CD27 on B cells in vivo during primary immunization enhances commitment to memory B cell responses. **J Immunol** 171:5876
2. Dani A Chaudhry A Mukherjee P Rajagopal D Bhatia S George A Bal V Rath S Mayor S (2004) The pathway for MHCII-mediated presentation of endogenous proteins involves peptide transport to the endo-lysosomal compartment. **J Cell Sci** 117:4219
3. Parameswaran N Samuvel DJ Kumar R Thatai S Bal V Rath S George A (2004) Oral tolerance in T cells is accompanied by induction of effector function in lymphoid organs after systemic immunization. **Infect Immun** 72:3803
4. Vig M Srivastava S Kandpal U Sade H Lewis V Sarin A George A Bal V Durdik JM Rath S (2004) Inducible nitric oxide synthase in T cells regulates T cell death and immune memory. **J Clin Invest** 113:1734

The Initiative: What has been your journey and how did you move or why did you move from medicine to larger questions beyond the medical?

Dr. Satyajit Rath: In the first place I don't think I moved to any larger question.

The Initiative: Then within the space of biology what has been your experience when you have tried to connect with certain areas?

Dr. Satyajit Rath: One of the issues I have faced, is the necessity of science education that is driven by the current situation. People, the general public, think that students of natural science are not good citizens, that they don't have value education, that they lack a larger perspective of knowledge systems and approaches to scholarship. These are undoubtedly true.

I think that integrated science education is of value but I don't think that these shortcomings on the part of the students are caused by a lack of education. I think they are caused by social, cultural, demographic, political questions and frameworks which are much larger. A large number of natural science students come from middle class or an aspiring middle class, socio-

cultural context and from that context the kind of position they take, which many of my liberal friends have justifiably asked, are derived from their life experiences and life situations. I believe that the presence or absence of integrated education is not really the key issue in this case.
So while I think that integrated education will contribute to knowledge, I am not sure that it will be filling in this lacuna and so change an educational problem besetting science students today. According to me it will take the form of a remedial add-on. I don't expect a radical change because of its addition. I do want to reiterate though, that it is of value.

The Initiative: If the political and the larger socio-cultural are issues of concern, then it is true for social science students as well. I get your point over then when you say the lager socio-political that is informing any student or any human being, so why must the science student be picked up for that sensitivity?

Dr. Satyajit Rath: Basically looking at science education from an integrated perspective is of value but I was pointing that out since the problem does not arise in the classroom expecting the classroom to make a change in the problem will be an expectation that is too large.

The Initiative: Some scientists we have talked to have suggested that there is something problematic in science education in the sense that connections are not made explicit, and students get into a narrower, a tunnel-ic understanding. It's not about integration. Some of the scientists we have talked to have felt that there is some lack in science education (in India) that we need to address. Would you like to respond to that a little?

Dr. Satyajit Rath: In the first place since many of the teachers are part-time I would be curious about not only about what *they* feel the lacuna is, but how they approach the lacuna in their teaching efforts. Everytime I have raised this question, in spite of the best of intentions, the answer has always been 'what can we do?' This makes me worry about whether they are articulating the problem appropriately or not.

The second level of response is for me the larger difficulty. Undoubtedly connectivity has not been made explicit. I think it's invariably connected to mediocre quality of teaching. Just as I

think that a great deal of our scientific research in India, is mediocre. What teachers really have is a crisis of competence in being able to teach, in being able to research. If you are a poor teacher, if you don't know your subject well, if you don't produce work which a scholar can find useful, if you are not sound in your subject then you invariably prefer to walk down the path where you do not need to connect with topics you don't know more about. I think the lack of connectivity is an outcome of the lack of competence.

The Initiative: Do you think it is an Under Graduate level problem or does it pervade the entire space of higher education?

Dr. Satyajit Rath: According to me it is a pervasive problem. This is my opinion not only about teaching but also about research. It is a problem which is driven by socio-cultural matter. We are a cultural community where jobs are given and retained by cultural considerations. The relative improvement of the standard of living in the middle class, particularly the increase in salary of teachers (in higher education) has exacerbated the problem rather than improve it.

I don't think it is much different anywhere else. The problem is that we, in our societal-cultural framework, have moved substantially away from traditional, feudal patterns. I think that it is the interaction of the developing projects with cultural practice that create problems.

The Initiative: We would say the same thing about the social science as well; the competence question is a problem that besets the Indian higher education space as such. It should connect both teaching and research

Dr. Satyajit Rath: What I am arguing for is applicable to both natural and social sciences. It also applies at the school level.

The Initiative: If this is the diagnosis of the problem, what will be your road map?

Dr. Satyajit Rath: If we say that this is not a problem that one can solve, the mainstream culture that a society adopts, is in a sense a negotiated political space and the only thing possible for us,

is to participate in that negotiated political space and perhaps that is the only solution. My argument is that using this statement as the starting point of the problem is misleading. So let me reformulate the question. Supposing we had a relatively sheltered, relatively protected academic scholarly space in which competence is not a problem. In such a situation, would introducing an integrated approach add value or not? That for me is the operative question about whether we should worry about a design for integrated teaching of social and natural sciences. I think the answer to that question will be an enthusiastic yes. Even if competence were not a problem, I think that providing a sort of interweaving of scholarly perspectives will add enormous value to the quality of education.

My argument is that integrated science education is valuable but we don't need to invoke the current dire state of higher education in India as a justification for introducing it because according to me, integration cannot solve *those* problems.

The Initiative: There has been a debate among us and among the scientists with respect to deep disciplinary rigor. The distinction between disciplinary rigor and this new found thing called interdisciplinarity. This debate has been preoccupying us. What would be your position on that?

Dr. Satyajit Rath: In the area of school education, both in formal and alternative efforts, many of us are worried about the tension between teaching regular scholarly text where one develops sufficient sophisticated understanding on the one hand (because that is what school students need for their livelihood and career) and on the other hand, teaching connectivity which leads to the development of different perspectives in order to create better citizens. A word of caution, certainly our attempt is to create good citizens but the idea of integrated scholarly perspective is not primarily intended to create better citizens. I think that will be a byproduct not the intended goal. Is the outcome at odds with deep disciplinary rigor? My answer is that if what we are trying to provide is sophisticated, scholarly perspectives then we are actually adding value to the capability of students to undertake this interweaving of domains of disciplinary works.

The Initiative: This helps us because we are trying to make a knowledge argument, rather than for value citizenship or consciousness? We are saying students need to be conscious.

Dr. Satyajit Rath: That's exactly what I argued earlier. 'Science students are so bad', is an inappropriate starting point for the entire discussion.

The Initiative: This is exactly what we argued in the IISER consultation - that we must not see science students as irresponsible citizens and that there is no reason to believe that the social science students are far better ones.

Dr. Satyajit Rath: There is a particular political ideology of the middle class which is reflected by all these students. All the teachers who worry about this issue are teachers who hold a political ideology which is at odds with the dominant political ideology of the middle class.

One way of looking at integrated education is to look at it as an explicitly political project. All this talk about 'better citizen' and 'value education' leads to this conclusion. Because it's not like writing something on blank slate. We are attempting to undo attitudes that we think are making them bad citizens. But out there in the real world, there are very large numbers of adults who are the democratic backbone of these politics. So I have no problem with undertaking a political project but we must recognize it as one. We cannot pretend it is an apolitical effort. On the other hand if we are going to stay within the domain of academia, then the argument an appropriate one - providing multi-disciplinary perspective- makes sophisticated tools available for elevation in the discipline as well as in the new area.

The Initiative: Can the political question be raised up-front when we are speaking to science institutions that remain in the given milieu?

Dr. Satyajit Rath: If I respond in statistical terms, the answer would be no. This is because the authorities at science institutions by-and-large reflect society and are therefore quite determinedly middle class in their political ideology. Therefore, they won't be welcoming any radical political project. Obviously there are exceptions.

If one had a political agenda as well, which I think one should have, the political agenda will be better served, as per my latter argument, to add sophisticated tool value and to build into that approach as a sort of secondary objective, where there are possibilities for political subversion.

The Initiative: How do you see the projects of dialectical biologists? Is there anything to learn from them or we need to do it our own way in India?

Dr. Satyajit Rath: I think there are things to be learned from them. I think perhaps they are a little too concerned with the forest at the expense of the tree. On the other hand, a lot of dead work is very much a biology-society interface approach. It is important to remember that in India if a 'great' educational perspective has to survive, it cannot be biology-specific. Therefore designing India-specific approaches will be important.

As I pointed out earlier, competence is a major problem that we will have to deal with in any new design. There the quality of incompetence amongst the biologist faculty community in India is very different from the quality of incompetence in the physicist faculty. Many biologists do not know the nuts and bolts of their basic biology. That is not true for the physicist community. That of course, does not mean that they are all competent. With physicists their incompetence stems from different sources. Attitudes and perspectives in different communities that contribute to and support incompetent approaches are qualitatively distinct in different communities. That is an issue that has to be taken into account when one is designing multi-disciplinarity as a part of education.

The Initiative: Whenever we talk of integration, we are for the most part speaking of biology. We are unable to bring up those questions in the physical sciences, an exception being energy issues. If they come up in physics, then they refer to philosophy of science, knowledge etc. Would you be able to suggest possible ways to go ahead, if it is to be not just bioethics?

Dr. Satyajit Rath: Starting courses that are biology-based is a useful entry point, even from a pure biomedical point of view. For example, if I am teaching vaccines I will have to teach some

social science. Though I understand social science to some extent, I do not know it well enough to cover it rigorously. So I seek help from colleagues who have worked on the history of vaccination, on the development of perspective in the sociology of advertising etc. Hopefully, then to teach the theme of vaccine, I would actually put together multi-disciplinary group of teachers. It is my hope that if I can do that then I will be bringing together a group of researchers as well as teachers.

The Initiative: Could evolutionary questions be one other such area which demands such multi-disciplinary effort?

Dr. Satyajit Rath: Relatively speaking it's a harder area primarily because of the distinction between facts and events, and ideas of what constitutes a fact and what constitutes an event …even between otherwise liberal minded biologists and social scientists. So it will be a challenging area.

INTERVIEW WITH DR. LEENA ABRAHAM

February 5, 2010

Leena Abraham is Associate Professor at the Centre for Studies in Sociology of Education, Tata Institute of Social Sciences (TISS), Mumbai. She has done research and published extensively on themes such as youth sexuality, educational and employment opportunities of urban underprivileged children and the social history of medical education. Her current research is on the sociological understanding of Ayurvedic medicine in contemporary India.

Recent Publications

1. Bhai-Behen, True-Love and Time Pass: Friendships and Sexual Partnerships among Youth in an Indian Metropolis, *Culture, Health and Sexuality*, 4(3), 337–353, 2002.

The Initiative: Tell us a little about your field and what hopes you have of science and the problems you think it faces.

Dr. Leena Abraham: I generally hope that science and technology would solve most of our social problems. A new kind of view that is becoming dominant subsequently is the growth of market, and the nature of capitalism and how science and technology have became powerful both materially and ideologically, so that even social sciences has begun to imitate natural sciences and its whole field of objectivity.

If I look at my own field of Medical Sociology/Anthropology it did not emerge from the discipline of sociology. Medical sociology started in the medical institutions in Europe because they began to see that there were problems in patient-practitioner interaction in structures within medical institutions, pertaining to issues of power hierarchy between practitioners and nursing

staff. So it is in that context that medical sociology started; it has continued in the medical institutions for a long time so it carries with it the legacy of the study of social relations within medical institutions. However, 'medicine' tends to mean modern biomedical institutions and the related institutions like medical colleges, pharmaceutical companies, so the focus became modern biomedicine in the European context. It was only about two to three decades later that medical sociology joined the parent discipline- Sociology. Due to the fact that it has been born out of this particular context it continues to look at doctor-patient interaction, compliance, institutional structures, bureaucratic arrangement and management deficiency.

So in the Indian context when people began to look at, or study the health sector from a sociological perspective they borrowed that history as well as the frameworks and so the concern at that time was on how to improve delivery systems, institutional arrangement, and health education. The last was onsidered crucial. After all this whole system came from somewhere else and it never really got culturally-embedded. Therefore an important task was to make people aware. These studies continued whether from a Marxist perspective, or from a functionalist perspective; they basically studied issues of equity and norms-values as if this model of health care is a given and that it is the best model for the country. This is because all countries are based on universal principles of science and of ethics – health for all and health defined in very narrow terms of certain specific outcomes and so on, which has generally gone unchallenged. It was felt that if it was good for European or American context, then it would be good for China, India or African countries-that it was a worldwide standard for all to follow.

But when they began to kind of implement these health programs in the 1950s and 60s, there was tremendous resistance! This is because one saw that there were many other systems flourishing and people were already negotiating with these systems easily. Anthropology in the 50s and 60s was concerned about how to make western medicine acceptable to these ignorant people. Anthropology and sociology arrived with very different objectives and history. Anthropology worked with communities exploring what they do when they have health problems. Sociologists worked with public health, planners, doctors and delivery systems and institution. So again there was the old divide from history and politics.

Even today, studying non-biomedical systems is very difficult because people feel it's not a very legitimate topic. It is believed that one is going against the two basic principles of public health - universalist health indicators as well as certain ethical guidelines to providing care to every one.

When I began my PhD work, I wondered why in Kerala which was supposed to be the most literate state, having being exposed to literature from all over the world that there are existed all these different systems. People would often shift between these systems, my own background reflected this. My interest lay in the fact that if these systems were based on different epistemologies, then why was it so easy to cross boundaries but not at the level of practice? All these three systems: Homeopathy, Ayurveda and Allopathy are quite strong in Kerala. So I became interested in the coexistence of these systems, and how people make sense of these systems and how they negotiate amongst them. That's why this whole interest in politics of knowledge started. I realized that a pure medical sociological perspective is inadequate. At that point I considered medical anthropology but it was insufficient as it did not look at biomedical institutions at all. It barely studied practices of indigenous systems in institutional settings. Rather those in a community they talk to Shamans, Jyotish, etc or else look at a text and find that it is inconsistent with the practice. Then I realized that it was important for us to take from medical sociology and anthropology (from the western tradition) and ask questions in different ways and see where it takes us.

So that's where I am now - studying how traditional knowledge reproduces itself in modern settings, taking Ayurveda in Kerala as a case study. What are the sites? What are the processes by which Ayurvedic knowledge is reproduced and recreated? What kind of institutional arrangements are available? What kind of state support is there?

So it's very difficult for me to say where I fit in today. In the Tata Institute we have a School of Health Systems, but I cannot be a part of that because its entire framework is borrowed from a western context. Within that whole framework, there is no space to examine what goes on in other systems, although you have a large number of colleges, trained practitioners and pharmaceutical companies in these systems. Still, we don't have an institutional academic space which will look at these issues; medical colleges certainly will not. These sort of issues are not

popular and one has to start from scratch, do extensive fieldwork and understand that the data does not fit in easily with many of the existing frameworks.

Recently because of the popularity of these systems in the West, there is suddenly some interest. Some studies have started in various institutions of South Asia for example, Centre of South Asian Studies. They call it 'CAM' - complimentary and alternative medicine. Chinese and South Asian systems are becoming popular there. The state is in a dilemma on how to handle these issues-the medical profession is so powerful that they will not allow the entry of these systems. So these systems are trying to make a backdoor entry through new age religious movement, as yoga, as meditation, because as a medical system it cannot!

The existing thinking allows for plural epistemologies in a field like health so that one can choose elements from these non-biomedical systems that are subjected to randomized control trials. These can then be incorporated into the corpus of biomedical knowledge. This is the only way or else these systems will stay outside the domain of medicine. If they were to occupy these peripheral positions then it is acceptable. (But then again, that is not happening today because they are making some inroads into the field of biomedicine). Chinese medicine is gaining popularity, homeopathy is making a come back, so the sociology and anthropology departments which studied only biomedical institutions or the anthropologists who went to Africa, Latin American and Asian countries to study indigenous, traditional medicines have now started looking at their own society where they are finding plural practices in the field of health.

The Initiative: Given this enquiry what is your understanding, how would a main stream science institution-a medical institution respond to this enquiry? Can the enquiry be within the curriculum, say, in a medical institution?

Dr. Leena Abraham: I am not sure whether the existing framework of mainstream science or of medical institutions will allow such an enquiry. Perhaps it would be possible in areas of extra curricular study because at a very fundamental level these enquiries challenge the superiority of science and objectivity. So in such a framework if anything that is being tested in the community (while using multiple methods) I doubt will find validity. It will not be considered on equal

footing in comparison to the tried and tested methods. Again just as in society, it has a marginal position in discourses in the field. However, that's not the case with people, people are utilizing these systems, and they are trying to see what they can do, how best they can combine it. This is not limited to the uneducated and economically poor. These were a common mis-understandings previously and to me problematic. Terms like non-biomedical systems are used, because of assumed ignorance and unavailability of biomedicine and superstition.

But all these ideas are also changing. What is interesting is that a lot of changes are taking place in the medical institutions in Bombay. Many of the leading private hospitals appoint Ayurveda and Homeopathy persons to manage their casualty department in the ICU. In this situation, the doctor needs to be present while the alternate practitioner will be doing what the nurses do - some instructions are given which they are supposed to follow. They however, don't make any decisions. They also get paid less. Similarly, the government is appointing these people in places where biomedical doctors will not go. This has been happening in Maharashtra for quite some time. In Kerala, I found that private hospitals were inviting well known Ayurvedic practitioners and offering them a wing where they could practise.

So in different ways there are combinations existing and it is not only due to patients exercising their choice for different treatments but where institutions are recognizing them as valid modes of treatment. However, the state does not announce this but once one allows these systems be part of biomedical establishments, they get a kind of legitimacy so it will not be easy to get rid of them.

I think the best comes out of interaction between these systems though I don't know how educational and training institutions respond to it. Ayurvedic curriculum has started incorporating, anatomy, and physiology and so on, along with some exposure to some basic surgical procedures at a very basic level so that they can deal with things that the biomedical doctors would do. One also finds a whole lot of these practitioners shifting to Allopathy; they are trained in Ayurveda and they practice in slum areas and make a living. But in places like Kerala you will find fewer of these practitioners because there is a general awareness in the community

and a certain political activism that does not lend itself to this way of thinking. If these kinds of cross-practicing are found there are immediately protests of ethicality.

There is a need to look into the sector within sociology and anthropology. Right now we are collaborating with a sociologist in JNU (Recently we had a set of articles in EPW, the first set to introduce it.) We are trying to get an edited volume so that we have some teaching material. That is the first objective in mainstream social science institutions - how to get these enquiries and make them a part of the mainstream. The next step would be to how to fit them in, in the sense, that one is likely to critique the other, they have the potential of creating foundational issues. One possible way of fixing it could be through extra curricular activities.

The Initiative: Just like sociology, anthropology is moving towards these questions. Do you think teaching sociology and anthropology would be valuable to medical students? Do they need awareness, if not proper disciplinary training?

Dr. Leena Abraham: Yes awareness is important, but in the Indian context if we introduce sociology and medical anthropology into the curriculum- (which are being taught in the western universities) I am not sure it will help students much.

The Initiative: So the configuration of those two are also necessary… they cannot simply be add-ons?

Dr. Leena Abraham: I used to teach in a Masters programme on Health and Hospital Administration. Nearly 90% of the students were doctors; most of them were biomedical doctors just like PSMB, you have to study to get that percentage so that you can carry on with medicine. I think it is important that even here Health and Social Sciences, Health and Development, Gender and Health should be done in the first module, because when the students come back in their second year they do not seem to have even heard of these fields! When you make it a part of the curriculum I don't know how it gets received. Unless there is explicit content which looks at whole history of medicine in both contexts (the history of medicine and health care practices in the pre-colonial period and also in the west) I am not sure of its reception.

I was talking to a surgeon once and he had no idea about the history of surgery in the west. He was talking about the low status of surgeons in the initial period, the barber surgeons and so on - because one starts with the belief that surgery is highly prestigious. Of course they do seem to know some things like how anesthesia became important, and how surgery developed from there and so on-(the instrumentation, antibiotics,) so there is some vague idea but no real historical awareness. They do not even know what were the conditions under which surgery was conducted?

I think now there is a wealth of material in the western context. It is important to enquire on how these knowledges came about and what their sources of power were. For instance, opening up Foucault who addresses the whole question of bio-power would be really helpful.

Along with understanding these different histories, it's also important to understand the local history. They don't even try and understand what happens in the field. As a first year student, one gets to see something, but in the fifth year then one already has the categories fixed therefore that is all one can see. It's also important to have these courses running throughout, what we should do now, is that in the first year we have to provide an introduction including sociology, anthropology, so that they are not neglected. Then in the final year when one needs to step into the field, there one needs to have communication skills, a little bit of the cultural context should be comprehended. This I think is insufficient. However, it's never given proper importance.

The Initiative: It, does in a way, answers a question. You were trying to argue that the humanities-social science modules in the IIT giving short courses in history and economics doesn't help technology students because they never integrate it into their learning and they see these courses as burdens. The connection is never made. In order to make the connection it has to be a continuous and historical and philosophical reflection on how knowledge has come to be in a particular field.

Dr. Leena Abraham: The other important point is also the reflection on anthropology and sociology that we need to have before introducing it so it's not anthropology that we need but a

revised, re-thought anthropology in terms of our systems, our necessities that can then become relevant. The scientists tend to think the humanities-social sciences are mere add ons.

You are also talking about marginalized views, so how does one bring that in when one talks about sociology of education? 'What about dalits', 'What about tribals', 'What about the woman', these questions keep coming up. Next semester I have developed a course on the women's body with the following topics: "women's knowledges; historical and feminist perspective" in the Women's Studies department MA course. I am going to look at the midwifery practices in the west and also in Asian context. What did colonialism do to midwifery practices and what kind of resistances came from communities and how some of these practices which were considered unscientific are now coming back; talking about peoples experiences, these knowledges, which you cannot test in laboratory.

Dr. Girija is an Ayurvedic practitioner from Chennai who is trying to do away with this whole baggage using the Ayurvedic method. The Tamil Nadu Department of Health has introduced some Ayurveda-based anti-anemia program for woman because they found out that the iron folic acid that they were distributing were being thrown out by most women because they caused constipation. When they introduced the programme they found that it was effective. Girija was trying to see to it that this doing away with physiotomy(?) might be introduced to government hospitals. Issue like what happens to these poor women when don't use western type toilet, sanitary napkins they tend to get easily infected. See the entire thing from women's perspective… women face these difficulties and problems defined medically and otherwise. What can we do to address that?

So you can see I am working on some sort of the very peripheral area within social sciences, to talk about how to bring these concerns together.

The Initiative: If it is for me to pull out from what you have said, I think I can pull out a number of points. To develop health seriously in one way I am going back to health but in an integrated manner, biomedicine but also acknowledge whatever interest eastern medical science can offer.

Dr. Leena Abraham: It's not a question of either-or, it's really not the way people use it.

The Initiative: If health establishments foreground the practitioners' perspective, we are doing a sort of study from the patient's perspective through developing narratives, but from the narrative some thematic analysis too, not just leaving them as narratives…

Dr. Leena Abraham: What kind of patients are you looking at?

The Initiative: The Karnataka studies reveal that 48 % of the people are going to western-type system and 52% of the people are going to non-western systems and also there is strong overlap. We are calling them user of services and not patients. What you have seen in Kerala… they are moving across systems. They have some other concerns. Systems and discipline are our concerns, but users don't look at it that way, they have altogether different perspective. That is something we are trying to develop… like share our learning, the critical moments.

Dr. Leena Abraham: What I am recently slowly discovering now is that in is this history of medicine in the colonial period and so on, we have do have some amount of literature but we don't have anything on the everyday practices in these hospitals. When I looked at Kerala I found that the first biomedical college started in 1951 where the first Ayurveda College supported by the state of Travancore started in 1889. I am now reading a lot of Malayalam material, biographies, autobiographies, prefaces of some of the books, some sketchy historical materials which shows that often Ayurveda practitioners or practitioners of integrated medicine in Chennai, did support the starting of some of these schools, so the products of that particular school - Ayurveda practitioners - were actually employed in these dispensaries, run by missionaries and the state. All text books including Amartya Sen, the health development report, say that biomedical facilities were available in Kerala from this period onwards. So I feel it's important for us to look at the history. Sociologists and anthropologists are saying that medical pluralism is a new thing, that it's postcolonial or late colonial phenomena. But it's really not the

case as confirmed by these historical documents. From late 1950s the biomedical system had started asserting itself.

In fact there was one single register for registering the practitioners of all systems, I think in the state of Travancore. Then the whole professionalization and division started. Many of these things are relevant in understanding the history of public health instead of only saying the first hospital was established in so and so year. I am always arguing with people on why it's important to look at this, purely from the point of sheer numbers - if you have 485 medical colleges training 35,000 students graduate every year and the comparative figure for the biomedical system is something like 320 colleges - some 34,000 students. This is the reality and then we say that all the documents one takes such as the health status of India, one will only find details of biomedical systems though they do have another small section - ISM(?) statistics it is called.

What are we going to do with all these people? We are training all of them. They are definitely going to shape the health sector in some way or the other. They seem to really know how they are shaping up because this is not something new; for the last few decades we have been training large number of practitioners. Where are they? What are they doing? I am so skeptical of these kinds of statistics when we even don't have basic statistics of how many people are doing what and where.

We can start from there… how did it come about? What are they doing? What are the politics of health care? How actually they are shaping the market? How is the market using them? These dynamics must be a part of any social science enquiry to health. I am not saying that equity issues are not important, but these two issues are closely related. I don't think we can discuss health without looking at culture! Health, culture, medicine has to be the core of any program when you are talking about integrated program.

INTERVIEW WITH DR GITA CHADHA

February 4, 2010

Gita Chadha has a bachelors and masters degree in sociology from the university of Mumbai. She was awarded a phd degree also from the university of Mumbai for her thesis entitled gender scientific institution and genius : a feminist perspective which is a study of the creative processes amongst scientists.

She has taught sociology at the undergraduate and post graduate levels in the university of Mumbai and at SNDT Women's University. She also has taught sociology for the University of London, External Study in Mumbai. She recently designed and taught a course for the women's studies programme at the Tata Institute of the Social Scinces on Feminist Science Studies.

The Initiative: Keeping the interface of natural science and human science at focus the CSCS-ISER tie up are having critical takes on social and scientific knowledge, philosophy of science, gender and science, colonial human science, I want to interview you in that sense where you have connected with other questions and would like to know about your trajectory as one other attempt where one reverse sort of connection has been marked.

Dr. Gita Chadha: My coming to the natural sciences was through a slightly different route. My school science understanding was almost the least. I now keep talking about the need to teach the sciences upto a certain level as I feel the analytical ability associated with the natural sciences is something that should be inculcated. I had completely erased the natural sciences from my consciousness… it was from the humanities into the social sciences as a young undergraduate student and also into social movement and justice and things like that. My coming to the natural sciences happened when I was doing my masters and I got interested in the method of the social

sciences which drove me towards positivism - how much we have borrowed from the method of the natural sciences. The whole concept of how sociology is not constructed as a humanity subject but is a social science, as well as its relationship with the natural sciences started the questions. It was about the method rather than the ontological thing… I think it was that which got me interested in natural science. I was going towards the ideas of holistic kind of a discipline, with things like Capra… very simplistic kind of synthesis that were being made and I found myself very uncomfortable with those because they were making ontological synthesis between eastern mysticism and western science, the Tao of physics kind of work. My journey began through that, and that is what fascinates me and I realized that the limitations in the entire discourse within the social science which critiques the methods of natural science and yet at the end of the day they continuously say that if we have to do anything which is non-commonsensical we have to have facts. The whole idea of challenging what is a fact and showing how a fact is constructed, that's how the critiques began - through its limitations of how to be applied in the social sciences.

Then I started looking at how the scientists themselves do it and probably realized that the practice of science is very different to the articulated method of science which is actually the business of philosophy of science. Then as I read, I got engaged with the ideological framework of Marxism and its whole dependence on the notion of science in its progress and my whole engagement with how primitive tradition - how do we look at tradition, how do we look at issue of faith in India, for example. So it was probably that engagement also which prompted me to undertake a critique of natural science, rather than what you are saying an engagement with it. I think that probably what we need to do is that while social science cannot give up the notion of objectivity, we need to redefine it. At the same time natural sciences are extremely canonical. Eventually it came down to how we can bring them closer? It was an issue of language.

Even as I undertook in my PhD a feminist critique of science, I faced the problem of how much of science do I really need to do for a critique of it? It was more of an engagement with scientific temper and scientific method. Eventually you get down to things like is it raising the paradigm for development. Of course, there is lots to indicate to us that science is deeply implicated in the crisis we live in and a more reflexive science is needed but that s not going to happen unless

scientists-social scientists learn to talk to each other. That's has been the effort for the last five year in terms of writing in terms of engagement – to sharpen the tools, sharpen the tools to critique, because at that point of time we were being accused that any critique of science is anti-science, therefore you are anti-progress, anti-development, and hence pro-right. That's a very difficult position to be in because you are not saying that and even you are critiquing a certain form of rationalism, it is not you are automatically creating a space for the spiritual mumbo-jumbo. In a dialogue with natural scientist, my first effort is to convince them that social science, even though it is positivistic, is an extremely important academic intellectual endeavor. It is very important to realize that the softer it is, the more it deals with complexity – the reality that it deals with is much more complex and you cannot be reductionist for in being reductionist you cannot explain much. So part of the engagement has been to try and sharpen ones own critical tools in order to neither sound nor be anti-science.

So it has been a question of how do you define science? Largely speaking, I have taken three kinds of triads in my understanding – one is sociological, second feminist and the third post colonial. In the post colonial, of course, the critique of science involves critique of enlightenment and modernity. When you are talking to a scientist, you have to keep on telling that the matter is contextual, it's within this context that modern science came to India, that within the context of modernity science developed. However, there is this whole question of universal science… they don't want to see that science being invaded by contextualization. But how much of science is really universal? One has to set limits to that and that is to not say that there is nothing universal over space and time. That's from post-colonial perspective.

From the sociological perspective, of course, we recognized that sociology of knowledge is privileged and sociology of science is privileged… science as a special system of knowledge because they compartmentalize belief and knowledge into two different things – and that is methodologically hara-kiri.

In feminism, I don't know where to begin for because it is not just about epistemological issues but to understand how gender and science actually merge together. That's the ideology but also that is a whole world continuously determined by technology. Turning away from technology is

not at all a solution but rather to negotiate a space for more informed use of technology. That will happen if there is a strong critique.

When it comes to a dialogue between the natural sciences and social sciences it is very important that the natural sciences learn from the social sciences because social sciences have become more reflexive, have asked questions of their own science and methods. That kind of critical thinking and reflexive thinking is what we need to bring into the natural sciences. We need to introduce as part of training of natural science critical thinking towards what they are doing. This is not to equate natural science to critical thinking but critical thinking should be applied to science as well.

The Initiative: The usual support that came from the natural science base for social sciences was the widening aspect – that it widens the horizon of the natural science. But you have raised a very important point that not to widen but insert criticality. And the social sciences offer a space of critical take on a very complicated reality. Because the reality is complex the method to approach it is also complex!

Dr. Gita Chadha: And therefore what constitutes knowledge becomes a very complex proposition.

The Initiative: And that that needs to be taken to natural sciences. A relationship between the natural and human sciences should have reflection of this.

Dr. Gita Chadha: And also an understanding of social sciences, you know. I think the basic problem is that there is no understanding across either disciplines – the social sciences don't understand natural sciences and the other way round. There are myths and assumptions that can be addressed. If they understand how the social scientists struggle to constitute what is valid knowledge. We are always in a crisis due to this. If I try to get standardized knowledge, I lose out on validity and insight, etc. I always cite Webber on this. He said that the social sciences are superior to natural sciences because they just don't offer explanation, they offer understanding and if this concept can be put through to the natural scientists perhaps we will succeed (to some

extent) in making them understand the type of disciplinary problems that social sciences have and possibly the kind of paradigm we can use in terms of understanding what is the difference between explanation-based knowledge and understanding-based knowledge. I want to make them see that the natural sciences are based on a continuum of ways of knowing the world. It is about cosmologies, different ways of explaining the world. We can choose our system of belief – epistemological egalitarianism – it's an idea which should be introduced and debated. Students should have a sense of this. I find a lot of them, they scrape under, they might accept it, its not that they deeply internalize rationalism and science, it is just a way of doing things and it works.

The Initiative: And perhaps at times this is restricted to laboratories. If they get out of it, they could do all sort of things.

Dr. Gita Chadha: Absolutely, it could be religion, it could be caste… these are all unexamined. What is synonymous with science is criticality and examination but they live an extremely unexamined world and they are socialized into being the scientist. So in some way it is about perhaps reducing the aura of natural science and lending some aura to social sciences that could perhaps help. Even it does not lead to self-criticality and reflexivity in the kind of science we are doing, at least it will lead to some sort of respect for different ways of knowing and that itself is quite important.

The Initiative: For instance, if you say you want history or history of science, I immediately have the problem which history in the history of science will come over because history itself has gone through so many twists and turns in the last hundred years and definitely in the last two three decades. The whole HSS base is haunted by '*which HSS*'. It has gone through a number of conceptual turns in the last few decades that the natural sciences need to also get exposed to and see how disciplines are internally trying to argue and carve out a space a sort of legitimate model of enquiry for themselves, which is sometimes lacking in natural sciences.

Dr. Gita Chadha: It's always difficult. The notion of science studies critique the discipline of social science from within its own history but also because of social movements from outside.

Science studies like cultural studies or post-colonial studies deeply draw upon critical engagement from within the canon but they also draw upon movement which social sciences did not. And knowledge is politically constructed. Any study, whether it is feminist studies, cultural studies, science studies, is a product of this critical engagement of the discipline with their own concerns and the social movements. What the movements tell us is also an important part and parcel of what constitute science studies.

When we were designing this course on feminist science studies, it was a very big question – where do we begin from, how do we design this course, what do we want to really tell them. I remember talking about science criticism like literary criticism. To develop science criticism, we have to understand what has been the philosophical history and sociology of science. So we did take readings from each of these and then we oriented them a little bit towards the sociology of science and knowledge because I deeply feel that the problem in these studies – science studies, women's studies, cultural studies – is that we don't ever ground them in one discipline. This interdisciplinary thing is sometimes problematic. If they understand the trajectory of science criticism in sociology, they find it easy to understand it in economics and anthropology and philosophy and so on. You can't teach them all the canons, so teach them at least one canon from where you move on to more complex issues of science criticism, specifically in feminist science studies.

We can't give up on the social science project completely while doing science studies but we have to draw upon the more critical things to do that. Sitting down to design the perfect course is one thing, but there is also the question of who is teaching. As long as they understand a certain moment – the environmental movement or the feminist movement – and criticize-critique some aspect of science and as long as they get some idea about how the social sciences critique them, it's good enough!

So how will the HSS at IISER go about? That is the question. They are beginning to widen the horizon. But widening also means being more critical. It depends on who are teaching and I feel it should be left open-ended. But this needs a huge assemblage of literature – material on

philosophy, history, sociology and so on. You have to have the material handy and it is a big challenge.

The Initiative: We actually agree with you that you need disciplinary rigour, they are vantage points from which you understand other things and that raises a problem for us: what will be the nature of HSS at IISER, i.e. which disciplinary rigor will be prioritized?

Dr. Gita Chadha: That's what I said – practical, open-ended. Otherwise an alternative is to start with post- colonial studies because that immediately gives you an entry point to the young students.

The Initiative: And also connects science, technology, development and western science.

Dr. Gita Chadha: Yes. And from there you have issues on philosophy of science – whether science is universal or not, etc. So you could take that approach, to start with one thing and then move onto others, but one reading each because people will not absorb more than that.

The Initiative: Yes, that has been another problem. We saw gender and science, if not as a theme, at least as an interface. So we identify interface problems, like colonialism and science or gender and science, which will give rise to a third space and some will be themes.

Dr. Gita Chadha: Through the interface, the themes will come. What we are doing – which is on gender and science – there are amazing number of works coming up in terms of forestry, soil management, agriculture and so each of these areas where these negotiations are happening in the interface space actually do through a theme eventually, through some very common, shared themes.

The important thing here is to get involved in the people's movement. The kind of arguments that come and the theme these movements actually suggest are very important. For example, if you are looking at gender and science as an interface, you cannot do it without the women's movement. So that is where the scientist's quest for politics is satisfied. They are not willing to

give social sciences the credibility of theoretical disciplines. The want it to be more and more applied. We were talking about the possibility of having themes, the first phase you do these interfaces and in the second phase you introduce the themes and movement. You will realize while you run the course, the most important thing is to make the students realize that they are doing serious academics and slowly introduce themes and the movements.

INTERVIEW WITH DR. VINEETA BAL

Jan 7, 2010

Recent Publications include:

1. Chaudhry A, Das SR, Jameel S, George A, Bal V, Mayor S, Rath S. (2007) A two-pronged mechanism for HIV-1 Nef-mediated endocytosis of immune costimulatory molecules CD80 and CD86. **Cell Host Microbes** *1* 37.
2. Rajagopal D, Bal V, Mayor S, George A, Rath S. (2006) A role for the Hsp90 molecular chaperone family in antigen presentation to T lymphocytes via major histocompatibility complex class II molecules. **Eur J Immunol** *36* 828.
3. Chaudhry A, Das SR, Hussain A, Mayor S, George A, Bal V, Jameel S, Rath S. (2005) The Nef protein of HIV-1 induces loss of cell surface costimulatory molecules CD80 and CD86 in APCs. **J Immunol** *175* 4566.

The Initiative: As a scientist and microbiologist why and how did you get interested in other questions? We ask you of you because we are interested as well in opening up other questions for our students.

Dr. Vineeta Bal: Well, originally I had trained to be a physician. Those days it was considered unusual if Physicians studied basic science. This was 30 years ago and to tell you the truth things have not changed much since then. This is all the more relevant in the Indian context, there weren't too many physicians who got into basic science. As I was finishing my internship and reading things beyond the texts required for passing exams I realized that my interest was not so much centered on looking at day to day patients and their care but something beyond that. There were two areas that were of interest to me. One was public health and the other was immunology. Public health interested me more while doing my MBBS because it was one of the

subjects we had to do. I really enjoyed those classes. With immunology my interest came when I was doing my internship. This time Immunology caught my attention more though I was trying for both. Immunology led me to research as an option because immunology practice was non-existent those days and anyway chemical immunology is rudimentary even today! I also had an offer of teaching preventive and social medicine, which I declined. In retrospective I feel that had I done public health I would have done it from a different perspective.

So I joined one project and then another one in Europe. That was probably the first project in immunology that I did. I never had a degree in immunology; my degree is MD in microbiology.

The Initiative: Did the public health concerns remain even after you were doing lab-based research?

Dr. Vineeta Bal: Yes it remained at the back of my mind. I had always believed that after my education got over I would like to be involved in work that was useful in the social context. Public health is a part of my interest because of my training in medicine. I did more work in women's health than public health. I moved around but the health-related concern did not leave me.

I came to Delhi 20 years ago and after establishing myself I began looking for a place to work where I knew woman's issues would be the focus. I also wanted to combine this with my interest in health. And because of my background I believed I could make able contributions. So I found Saheli. I joined it about 15 years ago. Saheli had a history of dealing with womens' health issues and I have been associated with them for a long time.

The Initiative: Gender has been an important concern for us in CSCS. And naturally health follows as a subset of it. Health has always been an important concern in the woman's movement but a problem that we are concerned with is the absence of gender in science. We would like to ask you if you have a route map on how we should go about addressing the gender question in science. It need not be in the 'should' mode but it would be helpful if you could offer us some reflections on the matter.

Dr. Vineeta Bal: Having one person deciding the course of action isn't a very good idea because there will be a person-to-person variation and that means a variety of good and bad results. Instead of that, some broad consensus would be good. Instead of formalizing and making it concrete: 'this should be the course of integrating the social sciences and natural sciences', we should begin modestly where we reflect on interfaces that can be created and built on. For example, I was thinking of ethics as one issue which deserves attention. As a medical graduate, there is the Hippocratic Oath that we are supposed to take amongst other things; but notions of ethics that medical students have are very, very variable. Amongst them they do not seem to question whether what is good for them is good for society or how should one look at it.

In different professions ethical issues can be dwelt on more. In women's health this is of concern to me specifically, the clinical trial: who gets the medicine and who does not and consequently this leads to the issue on what public research *should be* doing. These are one of the areas on which one can form a paper, it can be fleshed out as an area of integration of social and natural sciences. One can think of such an area even if it wont be coherent and completely integrated; I agree with that I cant really say how to do it but one should consider it because it affects people's day-to-day life and it has huge science component. But how does one be prepared will be of interest. Gender is something I am interested in, I cannot say I have thought through it how to build on it, how to introduce a course because many people are turned off by the idea. Every time I bring up the issue people are turned off. Since I am not exploiting, whatever is required or to be done, my conscience is very clear for I don't do it for personal benefit, and so I feel extremely comfortable in pushing the issue.

Completely fleshing out courses may be too ambitious, it may not work out in the IISER situation which is a concrete, active situation as against say the medical or engineering students and the IISERs are neither. They are chalking out their path for a science career rather than a medical or engineering career. Even the kinds of courses which will expose the students to the social sciences are necessary in medicine and engineering; in IITs also these kinds of courses will be useful.

The Initiative: Should these courses be compulsory?

Dr. Vineeta Bal: Yes. It need not be one single paper; if there are four papers being offered from social science perspective, and then at least one of them should be compulsory so that people cannot avoid them altogether. We need to have a strong programme! The commonly held notion by society is that the scientist have nothing to do with social benefit, even while being a part of the society. This is a feeling that is completely absent in most of the scientists. They have phenomenal faith in religion because it is their culture and upbringing but they actually have nothing to do with the society. I find this problematic. Developing four courses will be useful but I don't know how one should go about it.

The Initiative: Actually curriculum development has been of concern to us i.e., how to develop a curriculum and who will teach it?

Dr. Vineeta Bal: JNU has a teacher training workshop; many other universities have it. It is meant for university teachers to come and learn something new in their field. But somebody in social science, a historian runs a course which is not meant only for scientists, its humanities, natural science, social science teachers coming together, so it's kind of a Science and Society course. It is necessary for them to clear it (their promotions and things are based on that) and I think JNU conducts this course thrice a year. I talk to these people at least once a year about my usual Women and Science issue and Rakesh Batabyal who is the organizer keeps saying we need more such courses. They have these courses and they want Science and Society as one subject, and many more. I know it is meant for teachers but you are thinking of under-graduate and graduate. Even there I realized bringing up gender issues has a very different reception. It needs to be talked across ages, across professions, across all sorts of people and same is my experience about ethics.

Even in our institute for example, we have only PhD students joining and not in the recent past, but there has been changes in the way we teach and I teach immunology. There used to be one session where we used to talk to the students for a couple of hours about may be about my actual research work or anything that interests me. For two-three years, I talked about work ethics. You

have to prod and ask questions and students start responding, they at least have responses to say if such and such things happens whether it is appropriate and if so why? Those kinds of discussions can happen. I know these are driven by me in the sense what I think also matters but at least that was an opening that I used to provide that you should have such notion, you should possibly discuss with other people what is good or bad in terms of your behavior in the institute as a student, as a colleague, as a teacher, as a PhD guide. In a variety of manners I have tried it on an individual level but have never been successful in rooting it anywhere.

The Initiative: We are actually facing this difficulty now as we are setting up as HSS component as requested by IISER. Once we began working on it we found that it just wasn't easy. Actually we couldn't pin it down.

Dr. Vineeta Bal: Any cross disciplinary work that one wants to undertake, two-three discussions will not work. I, as a medically-trained person, who is a bench immunologist, who wants to work now with clinicians have to think of how to design a question, how to address it, so I am learning how to address it at a clinical level and my clinical counterparts are trying to understand how it is to be handled at a lab level. We have been talking for last six months and still could not come to a common proposal acceptable to all. So I can realize your difficulty.

The Initiative: We want to remain open-ended as we began work on it, say another way of being as inclusive as possible. So that we do not alienate the scientist..

Dr. Vineeta Bal: I am glad to hear that Tejaswini with her social science background and you with your mixed background are now trying to do that because I was also thinking that giving science-related perspective to people from humanity and social sciences is equally difficult, because its easy for them to say we don't understand what you are talking due to the lack of their science background. The other way round I wonder if any such effort is going on. In JNU in the social science school there is a community medicine department and I gather that 50% of the students taken are from medical background and the rest is from non- medical background. Both the streams sit together in the same class and they work on community medicine as a broad discipline. Here also they have to talk to each other and get a sense of what social science and

physicians are saying. I think working together, learning together also makes an impact and it's easier to do a give and take.

SHAHEEJ HEGDE

October 9, 2009

Sasheej Hegde has been with the Department since August 1998, having served before at Goa University. He handles courses on sociological theory, as well as offering courses on themes like legal pluralism, nations and nationalism, religion and law, and modernity and modernization.His research and teaching has concerned a subject area intermediate between 'philosophy', social and political theory, and culture critique: the question, specifically, of the enabling histories with which one works. More specifically, his areas of specialization have implicated three domains of inquiry: the Structure and Dynamics of Disciplines, the Interpretation of Modernity, and Research on Normative Political Languages.

Some of his recent publications include:

1. Epics, Indian Ethics and 'Theory": Thinking Through Matilal. *Contemporary Perspectives: History and Sociology of South Asia,* Vol.3 (2), 2009, pp.205-34.
2. Reassembling Modernity: Thinking at the Limit. *Social Scientist,* Vol.37 (9-10), 2009, pp.66-88.
3. Postnational Condition: Objections and Extensions. *Economic and Political Weekly,* Vol.44 (45), 2009, pp.75-79.
4. The Demands of Contemporary History: A Comment. *Economic and Political Weekly,* Vol.43 (40), 2008, pp.77-80.

The Initiative: One of the questions the ISE initiative is concerned with is the separation of the natural and human sciences and how this relates to large higher education university questions. As this is something Shasheej is also concerned with we thought we would get his reflections on the matter. We have been grappling with this issue of separation and the possibility/impossibility and the difficulty of bringing things closer and getting them integrated. It is in the context of science education that we are looking at this question but that need not form the focus of the discussion today. We would be happy if it did though.

Shasheej: the title of this lecture is "***Separation and integration of the natural and human sciences in the field of higher education: a new consideration***". What I am offering are some considerations on the theme. Whether this will translate into institutional or other initiative I am not sure. I use this opportunity to come to terms with some things that I have been thinking about in recent times. Before I start with the substantive part of my presentation I will talk about what has led me to the kind of thinking that I am about to present to you. There are two things that are important in this context. One is the imperative of my own thought processes-as I read through various domains of knowledge I am confronted with a set of questions that I will try to grapple with in the course of presentation. Then I must also deal with the imperatives of the title set by Anup that I must engage with. More importantly it gives me an occasion to go back to a small exchange between Charles Taylor and Thomas Khun. It's not an exchange that they actively cultivate but there is a response from Thomas Khun to Charles Taylor's essay called "Interpretation and the sciences of man". I found that much more than the challenge of Taylor's essay I found Kuhn's reflections on the questions a lot more illuminating. That exchange was something that always remained at the back of my mind. However it never cohered into a formulation. When I began to use that formulation it was only to reinforce other kinds of effects in the kind of ideas I was debating. Taylor argues that there is something special in the human sciences and that reflecting on the difference between the sciences of man and the sciences of nature might be necessary. He also highlighted that the nature of the objects in human science are markedly different from the nature of objects in the natural sciences. This is a very standard line of argumentation. What I found particularly interesting in Kuhn's take on Taylor's essay was. He makes the point that it is not a question of whether the natural and human sciences are the same or not but rather how the line between the two enterprises might be drawn. How do we

draw the line? Is Taylor's way of drawing the line adequate or are there other ways of drawing the line? These are interesting issues to address. It has implications not only for philosophy of science questions but has scope for engagements outside the theatre of the philosophy of science. I believe that Khun substitutes for Taylor's way of presenting the matter. The idea that "no more in the natural than in the human sciences is there some neutral culture independent of categories within which the population or objects or facts can be described" More pointedly, he insists that though the natural sciences may require what he calls a hermeneutic base they are not themselves hermeneutic enterprises; also he addresses why the human sciences are hermeneutic enterprises but still ask whether they are restricted to hermeneutic interpretations. Khun also asks "Isn't it possible that here and there, over time an increasing number of specialties will find paradigms that will support normal problem solving research." I think this resolution is some thing we need to keep apart but somewhere along the way that something hermeneutic about some disciplines and not hermeneutic about others is actually somewhere displaced. I always found this an interesting formulation but didn't know what further to do with it. Over the years I have engaged more with the normative questions more frontally and I feel more confident perhaps to deliver the kind of remarks that I am going to make. So this is one context in which I am formulating carrying forward a thought which was in that little exchange between Kuhn and Taylor but pushing it perhaps in a direction that Kuhn himself may have reservations with.

The second context, which I think defines all of us out here is: I think that most of us belong to a certain tradition of thinking which one can trace to certain strands of modern philosophy which attempts to mark out the limits in principle of modern scientific understanding contributing to health-human-self knowledge and in fact I look at my own years and the ways in which I was initiated into sociology and other human sciences was that there are limits to the scientific understanding and how science can contribute to human science understanding. In other words there is something distinctive about human beings. Much of what we try to define as human sciences issues from the recognition that there is something distinct about human beings. Somewhere along the way Taylor's essay is only anchoring this thought into a formulation.

Against what was called 'positivism' … . There was a certain radical edge that attached itself to this line of thought which asserted itself on the distinctiveness of human beings: that there are

limits to scientific understanding and that these are confronted when you begin to deal with human objects. So what I am trying to indicate is that different scholars push this issue differently. If I look at it from within the sociological perspective I would see that certain scholars are inheriting certain hard concepts of science but are pushing it-and not repudiating it; perhaps modifying it to work with objects that are distinctive domains of social sciences. One example is somebody like Durkheim. Another example is Webber. Webber in a way is handling this tradition head on and posing questions for this tradition in a way that introduces variations into the limits of science. Although in the substantive historical play, Webber has a larger argument. But methodologically one would get this radical ness from some of his papers. This radical practicality attached to thinkers who were objecting to the belief that the natural science paradigm was adequate to describe the human domain. While there may be degrees to radicality; if one were to look at Durkheim for instance, he did something to the natural science tradition by opening it up and using natural science methods in the study of society. If one were to also look at Webber; trying to sound the limits of the interpretative methodology and trying to argue that causal variables need to be taken a lot more seriously one sees degrees of this radicality. If we were to walk away from all these radical variations in the ways in which the possibilities of the scientific paradigm could be extended to the human sciences I think we'll find a more common concern which often derives from this way of thinking and which I think persists as a more complex problem. It is this that I want to get a measure of. In fact if we are all devoted to a project of examining this separation/integration of the human and natural sciences then the following set of concerns that I am going to offer to you are much more important.

Some of my formulations will get clarified when I have a lot more questions from you and then they can get contextualized in working out some of these thoughts. I am working for the context where one does have science working with questions that are traditionally considered to be the domain of the human sciences. For instance, science is touching upon questions of morality, rationality and the like. One can see scientists-cognitive scientists, evolutionary psychologists, neuroscientists working on some pf these themes. The question to consider is: how limited is scientific engagement in addressing those questions traditionally considered the domain of the human sciences. Is there a possibility of integration? Or should we have to reiterate the question of separation? This is the problem I am trying to address here. According to me getting a

measure of this issue is important for any project devoted to the separation and integration of the humanities and natural sciences. Today's lecture has a title that offers me the opportunity implicating both the notion of separation and integration.

I recall the C. P. Snow's 'Two cultures thesis' which has a specific contextuality attached to this thesis; spawned important debates over the years. These have come back to us and have translated into certain institutional initiatives especially in the context of Britain for instance, have not yielded the kind of dividends that was possible. My larger argument would be that if you were to re-invoke the C. P. snow thesis is that we would not land up anywhere. I think the basic problem is: what is the status one gives to normative consideration? And by normative I mean those that invoke some kind of an "ought" claim. There are two important "ought" claims: what ought to be believed and what ought to be done. I think somewhere along the way if there is something in the human sciences that can lend itself to a certain take these questions then it is something we need to engage with along this terrain. These claims are at the heart of the humanities. And in a sense they also contribute to the traditional case that the humanities form an indispensable core of any credible university examination system.

What is the basis of this claim? Of course these claims have gone into contestation. I will address them presently. While the considerations seem distinctly philosophical- I don't think they are confined to philosophy. I think they turn up everywhere. For instance, how should a text be interpreted? What does it mean to get a text right or wrong? How does a certain character's profession of a sentiment in a novel ought to be assessed? How are we to look at a painting? How do we establish the difference between contemporary music and something else? I am dealing with cultural objects and something implicit in these arguments which are problematic. Can these questions involve interdisciplinary cooperation with the sciences? Before I engage with that question, it must also be taken into account that science has engaged with these areas but how does one sound the limits of the engagement. I think this is important to address. The picture of the humanities which I am invoking is problematic. It amounts to treating the humanities as if all the humanities in different domains are all contributing to one single conversation. Or that whatever is happening within the humanities is one grand conversation about normative issues. This has become controversial and is legitimately contested today. It is

important to examine why it has become controversial today. It has become controversial within the humanities to treat itself in the way I have offered just now. I think there are a number of complex reasons for this:

One, there is a great suspicion in there being one way to engage with and address normative and ought claims. Or to claim so is to be viewed with a lot of suspicion. Can we address ought claims, engage with them without harping back to something else? I think because this has been problematised there is a sense that this objection has become very influential. Another objection is that first order normative claims have been so various and have changed so often that e have a better chance of explaining why people have to come have views of what ought to be done rather than assessing the quality of those claims. Maybe we could have straightforward empirical descriptions about how these ought claims are forwarded rather than getting into assessing the quality of answers that have been given to these ought claims. For instance, I remember while growing up reading this essay by Paul Ricker who speaks about 19th century thinkers who really were what he called 'Masters of suspicion'. People like Marx, Nietzsche and Freud. He uses the trope of masters of suspicion. I think this kind of suspicion has had a lasting impact on the domain of academics-in the humanities as indeed in the social sciences prompting a kind of shadowy scientism which I think amounts to saying that any cultural product, or any representative activity is always reduced to its psychological or social conditions of their production. To reduce cultural products to the circumstances of their produce can almost become a scientism of a kind as that position might believe it is interrogating scientistic positions on these questions. I find that this level of suspicion more interesting to work with; I would suggest that this skeptism about the independent or autonomous status of the normative is a necessary condition for those who undertake the empirical study of why people have come to believe what they generally do or did at a particular time, in a place and so on. In other words if there is no way by which you can resolve first order questions or normative truth then that's all that one would really think there is to study and research. There are other questions on could take on like studying why people have come to believe what they believe instead of taking on the validity of such a claim. This is comprehensible in a general way but I will elaborate further to make myself clearer. A great deal of humanities studies are devoted to objects not created for study. Academic projects are an example of this but many cultural products often whether it is plays written or

music of a certain kind or even movies; are not created to be studied. But there is a certain conjecture that all cultural products ought to be studied. If one were to look at the context of Europe it is only recently in the long history of the university that it has become considered the university resources be devoted to the study of cultural products.

It is understandable why we have some vague sense that an educated person should be familiar with some of these cultural objects. We have not yet settled on anything remotely like a common research programme for studying them the point I am making is independent of the claim that C. P. Snow forwarded 50 years ago when he made the pint that increasingly one is living in two cultures. He lamented the fact that culturally there was a predisposition to the humanities s and so on. So scientists would not know what it's like to read novels and humanities people would just not know what is going on science. He was lamenting the fact that two cultures have developed and the grain of his analysis was also to push in a particular direction. There was a strong response coming from Levis which came a few years afterwards. I am making these claims quite independent of those contexts that might be attached to those debates. I think it is this sort of uncertainty that has recently led some to more serious qualifications. I think even if some people are opening up to the normative and quite independently asses that there is a certain level of autonomy that attaches to the normative nevertheless I think that general tendency is to work towards more naturalistic observations. When I say naturalistic observations/descriptions I mean social science and humanities led descriptions which ahs incorporated the ethics of suspicion or the logic of suspicion. I am not trying to dispute that there are some valuable things to be learnt when the natural and human science take as their object certain representational and imagination directed human activities. The problem that I am interested in exploring is: What happens when such explanatory considerations are understood to have replaced or superseded what we have been calling first order normative questions. These are superseded in the favor of sideways or secondary questions. What explains/why people do this or that questions. Some may ask whether this is problem. I think in the context within which I am framing it, it is definitely an issue. If we are talking of logic, of an arrangement which incorporate both the dynamics of separation and integration of the human and natural sciences then something of the order of this question ought be asked and addressed. The point is that simply the two sorts of questions about what ought to be believed or what ought to be done are first order or normative questions. The

second order questions may be what explains why people believe what they do. The point is that these two sorts of questions are logically distinct and irreducibly different. In fact and the critical point on which this rides is that normative questions are first person questions and that despite all the context one might give to an event-the question that can be asked is that the event may not have happened-yet. Normative questions as first person questions need to be addressed. These questions are practically unavoidable and linked to social practice of giving and demanding reasons what we do. Especially when someone changes or limits what another might have been able to do. In fact I think these first order normative questions are unavoidable and irreducible. By irreducible I mean whatever might be our snap judgments or immediate reactions- no third personal test or fact can be relevant to what I decide. I may give a whole range of reasons for why I will not to do something but I still have to make decision about whether I will do it or not. There is something in the normative as a first order phenomenon that we need to address.

For instance, knowing something about the benefits of altruistic behavior might give us some perspective on some particular altruistic act. But for the agent in question, the decision must be made whether to act altruistically at all. Therefore this person will not stand by because he belongs to a species that has an evolutionary tendency to act altruistically. Thus though we may say that we are wired in a particular way- to behave a certain way there is still a large part that is distinctively the domain of the human sciences. The fact that we are wired in a particular way doesn't make the decision for us. I find this compelling for certain considerations.

It isn't so simple though-sometimes the reasons for why we act a certain way may not be known by us. Yet even then, the matter cannot be left there, especially when confronted by another and one has to explain.

Kant has said that everything in nature happens according to law. Human actions happen in accordance with some conception of law. There is a certain agential element which is involved which we need to take on. Somewhere along the way normal science descriptions is something which perhaps hasn't encountered this domain. So it is in this sense that the first person perspective is unavoidable. One is not a passenger in a boat being pushed along-one also has to steer. We are not guided merely by our social conditions or impulses we also are agents of our

behaviour. Therefore the agent's perspective becomes important. Besides, it is also compatible with the fact that people can often be self deceived. Or they may be ignorant of why they do what they do. They may devise stories or reasons for what they do, after they do it. -what are commonly known as rationalizations. There is no translation or no bridge law that will get one ___ agent from these facts about himself or herself to a claim that we are violating a particular way of being. My point is that the autonomy to the domain of the normative that I am trying to work with more actively than I ever did, is not a metaphysical one but involves practical autonomy and involves the status of the normative. I think it needs emphasis. This is precisely what has gone wrong in inter-disciplinary work. If you look at work that is trying to combine biology and say cognitive sciences and anthropology, the questions of what we are doing or what we are up to, are far more complicated than we will ever admit to in inter disciplinary work. If we are to talk of inter disciplinary collaboration on any theme then the immediate suggestion would be to take on board questions that I have indicated.

That's why I have always been asking this question: What do people have in mind when they speak about inter disciplinary collaborations? It seems to me that usually what people have in mind is applying some of the existing discourses to a certain area which has not made much progress. So inter disciplinarity may offer progress on a question which has not been happening. This attitude reveals a profound confusion about the humanities right from the outset. It reveals a lack of appreciation for the permanently unsettled naturally normative aspect of the humanities. That's why I think if any integration is to happen between the natural sciences and the humanities then I think in that process the integration has to reinforce their separation as well. They have to be brought together. I'm not sure how we will capture this dynamic within institutional initiatives and curricula reforms. I have faced these questions not just in integrated settings but also in the classroom where there is a need for dialogue between the different disciplines. So these are just some questions that I wanted to expiate on.

\INTERVIEW WITH RAGAVENDRA GADAGKAR

Jan 6, 2010, CCS, IISc

Raghavendra Gadagkar obtained B.Sc (Hons) and M.Sc. in Zoology from Bangalore University and Ph.D. in Molecular Biology from the Indian Institute of Science, Bangalore. During the past 25 years he has established an active school of research in the area of Animal Behaviour, Ecology and Evolution. The origin and evolution of cooperation in animals, especially in social insects, such as ants, bees and wasps, is a major goal of his research. By identifying and utilizing crucial elements in India's biodiversity, he has added a special Indian flavour to his research.

Gadagkar is now INSA SN Bose Research Professor and JC Bose National Fellow at the Centre for Ecological Sciences, Indian Institute of Science, Chairman, Centre for Contemporary Studies, IISc, Honorary Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Non-Resident Permanent Fellow of the Wissenschaftskolleg (Institute for Advanced Study) in Berlin and Adjunct Professor, Indian Institute of Science Education and Research, Kolkata.

Some of his recent publications include:

1. Gadagkar, R. (2001). *The Social Biology of Ropalidia marginata: Toward Understanding the Evolution of Eusociality.* Harvard University Press, Cambridge, Massachusetts, USA.
2. Gadagkar, R. (1997). *Survival Strategies - Cooperation and Conflict in Animal Societies*. Harvard University Press, Cambridge, Massachusetts, USA and Universities Press, Hyderabad, India. (Complex) Chinese language edition, International Publishing Company Ltd., Taiwan (1999). Korean language edition, Purun Media Publishing Company (2001).

3. Mitra,A., Saha,P., Chaoulideer,M.E., Bhadra,A. and Gadagkar,R. Chemical communication in *Ropalidia marginata*: are caste and colony signals conveyed through the same set of chemicals? *Submitted.*
4. Gadagkar,R. War and Peace: Conflict and Cooperation in a Tropical Insect Society. *Submitted*.

The Initiative: Your journey as a scientist starting from your days as a science student. You were already then oriented towards social questions or larger cultural questions.

Dr. Ragavendra Gadagkar: There are two kinds of things that should be made clear here. One is that I was interested in larger questions, in society, in philosophy but two; I was also interested in scholarly disciplines. I could equally envision myself in some other department as a student. It was just sad that one could not be in all of them at the same time. As disciplines of education, I was equally interested in all of them. So I settled by having friends in other departments. As students one can freely interact between departments, but as faculty you don't have that freedom. Even in the University, where all the departments are represented, the faculty did not interact, at least not at the scholarly level. This remained with me for a long time. So at two levels I was very affected.

The Initiative: Why did you go towards the natural sciences?

Dr. Ragavendra Gadagkar: Well, there was a streak in me that said I would always go towards the sciences. There was no doubt in my mind. But the sad part was that it was at the expense of doing other things. I wanted to do science without moving away from other things. At one point, my Hindi teacher was convinced she could persuade me to get into Hindi literature as I was very interested. For me though, if I had to choose it had to be science. Still the isolation was paradoxical and painful for me.

The Initiative: What then opened you up as you moved through the sciences?

Dr. Ragavendra Gadagkar: I had finished my BSc, and MSc. But what remained with me was the reluctance and inability of people to communicate with each other, the most spectacular failure of the academic community. For instance, the biologist cannot sit in a scholarly group of sociologists and understand their language. They speak different languages, it's like putting a Russian and an English person in the same room and making them communicate. In some ways worse because in that case you know you don't speak Russian so you don't try to interpret. But here you have the ignorance of your ignorance. This is why science is misunderstood by non-scientists or those from other disciplines because you understand the words but not what the sentence means. It is the most spectacular failure of the intellectual community and we are comfortable with it.

The Initiative: Is this also not a problem with social science space?

Dr. Ragavendra Gadagkar: Oh yes, there is complete symmetry here but this dichotomy exists even between social sciences, say between history and philosophy. It is a matrix with isolated subjects. It is more like there are three compartments here.

The Initiative: While this is completely true in the social sciences, is this less true in the Natural Sciences?

Dr. Ragavendra Gadagkar: It is not true but the perception is there and there is a reason for it. In the natural science it is easy to see the "layman" has not understood so there is a greater attempt to write a different text for their consumption, generally called popular science. There are any number of books written for the non-specialist. This is common practice in natural sciences but not in many other sciences, perhaps an exception is history but still there is not any attempt to communicate the methodology. This is attempted in natural science, there is a great deal of description of how you came to a certain discovery, what attempts you made. Because you realize that you are not being understood, scientists realize the opaqueness of their technical language. Things get that specialized and because of these attempts there is a little more understanding. Nearly all branches of natural science have created text books for the common man but not the corresponding things in other areas. Perhaps a few in philosophy, or history but

not popular history as in the case of popular physics. It is not the technical discipline that is being distilled. This is why there is the perception we are understanding more in the natural sciences.

The Initiative: This a positive attribute but coming to the practice of science in science institutes, would you say interdisciplinarity is deeper in the natural sciences than human sciences?

Dr. Ragavendra Gadagkar: Interdisciplinarity has been born many times in the natural sciences but it becomes so deep and entrenched that you do not realise it as interdisciplinary. Biochemistry is a merger which is a merger of 2 fields. Taken to their logical conclusion, in happens in episodes and they are very deep and they become new disciplines. That is the final proof that you have become interdisciplinary, is when two disciplines become a new discipline.

The Initiative: Is there any possibility of natural science and human science doing this or is dialogue the only way to go about it?

Dr. Ragavendra Gadagkar: If you had asked me a few years ago, I would have said probably no. Now I am becoming more optimistic, not because people are suddenly becoming wiser but because necessity will make it happen. There are areas such as climate change. This is an area where you have no choice but to do this. It is inescapable that historians will see a continuum between human history and natural history, and this will lead to a clear merging of biology and history. It is not at horizon anymore.

The Initiative: The contemporary is throwing up interesting new questions and it is making it important to connect. And what is a discipline after all?

Dr. Ragavendra Gadagkar: The discipline only decides what size the room should be or how to pay salaries. I can see no deeper function in disciplinary boundaries.. one cannot see the merit in this.

The Initiative: Coming to the CCS experience, what would be your reflection on the history, growth and trajectory that you and CCS space have taken.

Ragavendra Gadagkar: From the point of motivations, there are several.

5. There is the shock that we live in these disciplinary islands and something has to be done, however small it is.
6. The second is that being at IISc where there is no possibility of having a coffee with someone doing something else. In IISc you do not even do that, there is much greater isolation, no opportunities for social, non-technical interaction. I want to see what a person doing research in music looks like. It is my great frustration that you don't even casually run into someone here. You can believe that the whole world does the same thing as you do and my worry is that students do believe it, they spend 5 years here in complete isolation, as if there is no such thing as another discipline, a genuine one. People should be exposed.
7. How to do your own science? Natural science is becoming increasingly sophisticated, expensive, technology-dependent interface in all its branches. Which means there is greater disparity between different people, countries, between universities, between labs, in your ability to do it which has nothing to do with your intrinsic competence. It has to do with externalities. This is a serious matter. Perhaps it is not as important in say literature. Here the playing field is very uneven... because of this dependence on technology, infrastructure, money. It is not that the intrinsically competent will come up with something. We are not going to get suddenly a noble laureate in Tumkur University. Intrinsic abilities are randomly distributed in the world, these other factors are extremely not randomly distributed. People not in the most endowed situation, it can be Harvard and Amherst, IISc and Bangalore University or Bangalore and Tumkur, have to find other ways of getting ahead. In Natural Science, this would translate as having a different perspective on the same problem, not the usual way. Design an experiment that guy in MIT has no time to do because he has his path set. Buying the same kind of equipment that guy in MIT has will not solve the problem. He will always be one step ahead. Trying to run faster on the same track will not really help. So to overcome this limitation we take a detour, looking at it from the other side and exposure from other disciplines will help in this. So that people in underdeveloped countries can compete.

8. The most ambitious of all of this is that it is my belief that the hardest thing to do is to question the foundations of your discipline. Questioning the foundation of any discipline is intrinsically very hard, and even practically very difficult because you are competing with everyone else. It is easier to build one more floor to the existing structure than to tear away the foundations. How does one even begin to create a wedge to do this? And while it is hard, it comes easily to question the foundations of someone else's discipline. For one, the cost is much less as you are coming as an outsider. The practical reason is that you slow down, you have less familiarity. An insider would not even think of it. Familiarity blinds you to different ways of doing your own discipline. If you do it of someone else's long enough and publicly, you will one day start thinking of your own. Familiarity blinds you to different ways of doing your own discipline. So this is my long shot is to question the foundations of some other discipline may produces the wedge through which they become aware of their own discipline. Then you begin to reflect and wonder... this is the condition to question the foundations of one's own discipline.

These 4 motivations are very real and what we are trying to address here at CCS.

The Initiative: What we can see here is that both points 3 and 4 are crucial because they are making knowledge arguments, that it is critical to integrate the sciences. Not for the value education of science students, that is to see science students as value-depleted and social science students as value-endowed. Science students can well be value-endowed. Here we make a knowledge argument.

Dr. Ragavendra Gadagkar: Here it is very clear to me that while the most of the points will translate or migrate from the natural sciences to the human sciences very easily but I am not sure if the 3rd will. The need and ability to use a different track. It has nothing to do with technology or money but to create an intellectually creative space what will reward something like this. But I don't know enough about this.

The Initiative: Did you face any resistance when you were trying to go this way?

Dr. Ragavendra Gadagkar: That was a surprise but no. I was lucky. I was in Berlin when I got a phone call from the Director's office to set up an appointment. I went for it and it was resolved that they were setting up CCS and I was to be the Chair. He didn't say anything more. That means that officially the centre had been set up, it was in the books, it had a building, secretary and all of that. And the model I had wanted required very little money.

The Initiative: What would you suggest for the IISER model?

Dr. Ragavendra Gadagkar: It should be different because they have undergraduate students while we have mostly post graduates. What should the different model entail? If it is possible to have a different model, my suggestion would be a liberal education with lots of choice. In my mind it is arrogance to believe that a person who has done biology, political science and music is good for nothing. How do we know what that person will create? We cannot imagine what will be created. It is as we are running a factory and we know what we need. But we are not aware of what this world needs. The IIT model is not a useful model. It has problems for both students and faculty. For students, they may get no real exposure to HSS but for faculty it is their livelihood. At IISER this is difficult but in universities, this is very easy to follow through. It does not cost anything more to do this. If there is an alternate model... at IISER this kind of model but amplified in some way. Courses can be compulsory or optional and make these courses available for credit and make it more structured.

The Initiative: Who will teach these courses? How will it happen?

Dr. Ragavendra Gadagkar: I would prefer a Visiting faculty model over a summer school model. The summer school model is optional; there is less structure and no credit. Mentally it is something else, in the summer holidays. It is not a part of the curriculum. Instead get one or two famous people to spend a semester for a course. It adds flavour to the curriculum and the students come in for the big figures. Subjects can keep changing and it will enrich the academic atmosphere. And it will fulfill all my four points. It would also amplify the CCS model.

The Initiative: Should we open it for social science students?

Dr. Ragavendra Gadagkar: Yes. Make it public. All kinds of people attend our lectures. IISER will become an academic hub. I am sure it is possible, if they find the right people. My advice would be to teach the topic, the methodology, the line of enquiry and not the discipline.

INTERVIEW WITH DR. RAVI SUBRAMANIAN

Feb 4, 2010

Dr. Ravi K Subramaniam has done his B.Tech. in Aeronautical Engineering, 1984, Indian Institute of Technology Madras. Bombay. He went on to do an M.A. in Philosophy, 1995, University of Bombay followed by his Ph.D. in Philosophy, 1992, Indian Institute of Technology. His areas of work include: Mathematics Education at school level: Development of curricular and co-curricular teaching materials, teacher training and teaching students; Research: Cognitive aspects of mathematics learning, Mental representations in reasoning and problem solving; Science and mathematics popularization: Through lectures, exhibitions and books, including some on history of science and mathematics.

Some of his recent publications include:

1. Subramaniam, K. and Mazumdar, A. (eds.) (2009) Proceedings of epiSTEME-3: International Conference to Review Research in Science, TEchnology and Mathematics Education, New Delhi: Macmillan India.
2. Subramaniam, K. (2001) Maths for Every Child, Part A, Text-cum-workbook of the Homi Bhabha Curriculum in Mathematics for class 3, Mumbai, Homi Bhabha Centre for Science Education. Translated by H.C. Pradhan and A.T. Mavlankar into Marathi as Sarvaansaathi Ganit, Bhaag Ek, 2002.
3. Subramaniam, K. (2001) Maths for Every Child, Part B, Text-cum-workbook of the Homi Bhabha Curriculum in Mathematics for class 3, Mumbai, Homi Bhabha Centre for Science Education. Translated by H.C. Pradhan A.T. Mavlankar and S. Naik into Marathi as Sarvaansaathi Ganit, Bhaag Do, 2002

The Initiative: As a part of the science initiative our interest lies in looking at the natural science human science interface. One question for you would be how was it possible to make this transition from your PhD on Heidegger and the question on history to the natural science space?

Dr. Ravi Subramaniam: With regard to my personal trajectory I did my under-graduation in engineering. During that time I realized my basic interest was not in engineering and I had the strong inclination to shift to some non-engineering department. One of the factors that influenced my wanting to shift was the existence of humanities and social science department in the IIT. Right in my second year I audited a course of the PhD level in psychology which was called 'models of manners'. We did original readings from Freud, Ericson, Jung, right up to Karl Rogers, Adler and so on. Looking back, that was one of the fundamental influences. Not because the course was in psychology but the manner of doing(teaching and learning) the course. It was based on reading and presentations. The students who were participating in the course were PG students, PhD students in HSS or a few MTech students or PhD students from other department would participate. So they would read and make presentations. Since I was in my second year I was considered too junior to make presentations. But I did a lot of reading.

I started spending more time in the HSS department as an under graduate student. I took much more than the requisite number of credits in HSS, I took as many courses as possible in HSS. Quite a few of those courses were related to science and technology policy and the relationship of science and technology to society. There was also a group active at that time called PPST whose meetings I used to attend. I was there from '79 to '84, it was one of the last 5 year batches. Reflection on science, science policy, technology, technology and society, technology and culture, appropriate technology, were the kinds of questions that interested me at that time based on the courses and readings in HSS.

During the end of my PhD I decided to join a program in economics which looked at the relationship of technology to development and economics. I applied to CDS and IIM Calcutta which had a fellow program in Economics. I got selected in both places but didn't join for some reasons that are personal. I wanted to stay in Bangalore for a year and hence started an

engineering job, at a defense lab, DRDO. I worked as an aeronautical engineer. I thoroughly enjoyed my job. But by the end of that year my interest settled on philosophy. I don't think this decision was taken on the basis of some deep reflection. Quite a bit depends on the existence of role models. There was an older student who had done his Btech and Mtech from IIT Madras and then enrolled for PhD program in IIT Bombay in philosophy. I heard about it from him. I came to know that the admission was on the basis of GATE score in which I had fared quite well. So I found no difficulty in getting admission in PhD in HSS and I enrolled in philosophy. By then I was reading people like Foucault quite a bit, German thinkers of the Frankfurt school, Habermas, I got very interested in those debates. I discovered a whole lot of German thinkers who were influential in twentieth century philosophy. I decided to do my PhD on one of them, Heidegger.

Reading people like Hegel and Dilthey's philosophical understanding of history, their questions of change and development ultimately leads you to take some perspective on history. I was also very interested in reading history books. This promised to give some kind of deeper understanding of meaning and significance of history. Coming from a post-colonial society under rapid changes, my own childhood being in a completely different kind of setting we went through many changes. Looking back at these made me sensitive to these questions and I decided to do my thesis on history and on historicity. How does historicity influence philosophy and what is the stance that philosophers take with respect to history? Hegel or Dilthey or the social sciences take a certain kind of stance and I thought there was something different and fresh in the philosophy of people like Nietzsche and to some extend from that line to Heidegger. So I looked at Heidegger. There was some interest in existentialism in the department at that time and so there was quite a deal of receptivity. I worked on hermeneutics, historicity, philosophy of history and other social sciences in general and Heidegger. And also being from a technology background I got interested in the question of technology in Heidegger. So I tried to link up this critic of this picture of world history and that is what I had my thesis on….

The Initiative: This clearly shows the HSS course did do something good in the IITs. Would you agree?

Dr. Ravi Subramaniam: It is wonderful to have a HSS department in the IITs. Students who come are bright, many of them like to have their own views but they hardly have any exposure. They enter the institute at a time when they are not well exposed. At least that was the case in my generation. I don't know whether it's different these days. I hear that more students still come from small towns than from metros. I think it's a place for great exposure and having a strong HSS department is one of the best things in the IITs, according to me. I believe this even though all the students are not necessarily influenced or impressed by the HSS department, part of the reason being the quality of the department itself. Being in an institution like the IIT, the HSS is in a peculiar position, it does not get its due, which ultimately affects the quality of these departments. But obviously if you have a very strong department it would make a much deeper impact on the students. These departments influence a very small number of students. This happens when individuals in the department start to relate to some students. I related very well with Prof. Rajgopalan, who was in the HSS department at that time. He had an engineering background. The department at IIT where I was a student, the department of HSS, I think played a major role through its courses in philosophy and literature.

Of course psychology is always useful to BTech students because its one step into management. So those who are doing a MBA or preparing for GMAT after btech, its useful for them to have a course in organizational behavior or principles of management and so on. But apart from that purely liberal arts kind of courses like literature, philosophy is fairly strong in the IIT. Students are very much influenced, particularly by literature. I know a bit about the HSS department in IIT Kanpur, one of its strength was the history and philosophy of science program, which was well anchored in the department through.

Since I finished my PhD a question might be how did I made it to this place, the Homi Bhabha centre. I couldn't get a job very easily in a philosophy department since I didn't have an MA so actually I went for a MA program and got my degree some three years later. Meanwhile I went to teach engineering in an under graduate college. I wasn't keen to teach philosophy in the academic departments. The emphasis, the culture, the style of functioning was not attractive. I gave up even trying for such job and meanwhile I got to this place and here it was very interesting for me. When I joined I taught courses in history and philosophy of science, and there was receptivity to that course which was very unusual! It really struck me because the lecture

course, it was a graduate course, we hardly had any graduate students, the faculty would attend the courses and there were a couple of PhD students from TIFR who would come and attend the course. It was very engaging and interesting for me. So I caught on my reading on history and philosophy of science. We did two courses, one doing the classics and the major questions, and two focusing on more contemporary trends in philosophy of science. It was only faculties who attended the course. It was time of change in the centre because it was expanding at that time it was getting much larger number of facuties from just a handful. They just moved to this new campus…there was a change in directorship. So there was expansion and development type of activity. So we worked on some project on history of science, my colleague actually coordinated the exhibition which is there down stairs. There was an earlier version of that exhibition in which we were all involved. So there was quite a bit of fun. For some reason again I began to focus on mathematics.

The Initiative: One of the criticisms that have come up is that when these avenues are opened up for some, and I have been criticized here, that we loose our connection with science. We end up becoming either history, philosophy or some of these people.

Dr. Ravi Subramaniam: That can't be said although the science and mathematics that I deal with is of a fairly elementary kind, I keep in touch by reading some lectures and so on with a little bit more advanced stuff but largely of the undergraduate, masters level. So I had the good luck of keeping in touch with stuff especially mathematics. So lets put it this way – its not that I was not interested in science and mathematics I was probably not very keen in engineering particularly because I didn't see any connection between engineering and what I perceived as important questions in the society at that time. I think, as Gadamer says, there is a philosophical element in the sciences which has a universal appeal, and that is attractive, that's something of the core. For science or mathematics education to be universal in some sense that philosophical element must come to the forth. I think that is part of our own self understanding the way we are in the world, part of that understanding is definitely understanding of high intellectual achievements in these domains like science or mathematics. That's what I see as the major hold of my work, although I do not address them very directly. I am more engaged with practical issues like pedagogy, curriculum reshaping, restructuring trajectories of learning, but my main

interest has always been universal education, mathematics for everybody and in that the philosophical aspect is very important. How thinking about the world changes through the development of science and mathematics, the stories are very long and its much broader than science or mathematics if we understand it correctly

The Initiative: So do you think this is lacking in science education?

Dr. Ravi Subramaniam: Well there are many many lacks in science education. People have talked about appreciation, many thinkers in education have used this word, to denote that even if you don't learn something because it's useful to you you learn something because it has some intrinsic value in knowing it. So now obviously universal science education or maths education must have appreciation of achievements of science or of mathematics as one of its goals. So it's quite central to maths education or science education and its something someone will like to see emerging in science education and maths education.

The Initiative: What are the other problems with science education?

Dr. Ravi Subramaniam: Working with education has one advantage and that is if you are dealing with a fairly narrow question it soon blows up into much larger, much more general question. I think and work on mathematics pedagogy, but it soon blows up into bigger issues, like: What's the relevance of mathematics? Why should children learn mathematics at all? What's the relationship of mathematics to life? What's the goal of education over all, whether mathematics is serving that goal or not, What is the social milieu in which education takes place? What are the larger social forces that shape it? One is forced to address broader questions in the maths education research community which has been reflecting and collecting data, developing ideas, through disciplined work of research for the last may be a century or so. It began with a very strong grounding in psychology, educational psychology and pedagogy. So that was the connection from where the research community grew and emerged. When some people with a mathematics background started advocating the necessity of integrating psychology in mathematics, this changed mathematics education. But now psychology itself has evolved by shifting from cognitive psychology to cultural psychology to realize the fundamental role of

culture in shaping thought. And that had its echoes in mathematics education research as well. People have become sensitive to the influences of culture to the kinds of learning that students have outside school. Surprisingly in mathematics there is a considerable amount of learning that happens outside school. It comes as a surprise but it is true. There are good reasons for this because many of the students who come from impoverished backgrounds are engaged in small economic activities. And there is a certain kind of mathematics which is operational which you need to learn in those situations which are completely outside school curriculum. The schools' curriculum is in complete opposition to these. I think in the last two or three decades has been the growing realization that this is something which is completely undesirable, these kinds of separation, and that one must think of the connection between these more deeply in both directions. How can school mathematics take advantage of the culture and mathematics that currently shape mathematics in the culture and also the other way round, how can school mathematics influence and shape culture. In fact recently I argued that traditions of knowledge can be sustainable for a very long period of time and can go on flourishing only if they have strong cultural roots. The sort of modern knowledge systems that we have inherited or acquired from largely outside don't have those cultural roots they are unlikely to sustain and flourish in our culture unless they have a cultural root. We are also being blind to penetration of knowledge in culture, we don't understand the process of how knowledge really takes root in culture. Appreciation, using knowledge for art, for economic activity, all that is a part of that. We haven't talked for example how science is linked to art, to performative arts, to other kinds of art, to music, to story telling, I mean various things in culture. These issues are quite relevant in education, because education is the site where there is renewal of culture and if one is thinking about how this knowledge can take deep root in culture then education is the site where it happens.

The Initiative: OK this is actually interesting, this is something new that has come up. You have brought in I think a different argument of why people require at least if not an integrated approach, a broader approach without which even science education suffers.

Dr. Ravi Subramaniam: Absolutely. Unfortunately there is another thing I would like to say. Currently the main mode of attracting people to those activities which involve more creative

aspect of engaging knowledge, (science research) is through main stream schooling systems. Now the main stream schooling system in a culture like ours is strongly influenced and shaped by a culture of competitiveness. That's again is a result of larger social forces. This is very unfortunate, because what you get as a result of intense competition is a particular kind of student profile. I don't say a particular category of students but the students themselves are shaped to think this way. Its not something that is sustainable in the long run without the other aspect of taking deep root in the culture. Students coming from pure and sheer interest, and delight in these kind of activities, thinking and taking delight in that philosophical element of reflection, about reality about the world about particular aspects of reality that science deals with, and about the connections of that larger questions.

Ultimately science research is driven by deep questions, even though you may be researching on a small thing, you may be studying what is the influence of some particular chemical on the emotional behavior of a rat, but questions at the back of your mind are how are …what are the forces which shape us, how do we understand ourselves. That's a deeply philosophical question. That drives our specific interest and it sustains and allows to make connections and to expand the whole. That's the source of creative urge. So you need that. You cannot have a system where competition alone determines your entry into a research career. Of course we are trying to improve and refine those systems of competition. You need to think of other things, for example many students are turned away by the competition, they are turned away by the narrow focus of what goes as scientific research. In fact we turned into other areas like journalism, or the social sciences or history or something like that which seems to be dealing with larger, more real issues of great import. Young students who look at science as something which is narrowly focused and entry to which is largely governed by competitive culture is likely to be turned away. There are many bright students who possibly could contribute creatively, of course there are many students who are excluded for other reasons, like social reasons, of course we are a developing society with strong social strata, so many students do not have access to the kind of education that you need to participate in knowledge seeking.

The Initiative: The way you now put it, would the HSS departments be enough or sufficient to address these questions, or do we need to develop a model, the way now you have put it, becomes a sort of concognant with science education?

Ravi Subramaniam: I would say as a student as I became interested in humanities I lived through a certain tension, I lived two different worlds, in some sense schizoid existence, may be there is a way of not having these. I remember in the second year when my interests were developing I happened to watch the *ascent of man* series and it was fascinating and I became deeply interested in mathematics and in history of science at that time. But there was no opportunity to pursue those interests. What was available was core humanities courses because nothing connected the dual concerns. That might have allowed me to strengthen my interest in sciences also. Of course engineering is a different ball game, its not that I had no interest in engineering, I worked fairly well for one year in engineering, I like tinkering with things although its not my main interest. However the pull of science, the pull of things which are more intellectual, more philosophical, which makes you reflect deeply is much stronger. Its something which I can't resist. This is something which was not present in science and mathematics department in these institutions which were largely focused on engineering. Even the science departments they were seen as tool departments, they were furnishing tools of science, whether its physics or chemistry or mathematics, it is basic tools you need to acquire in order to learn engineering. I don't think they did justice to science or mathematics. That would have been good. When I read the Yashpal committee report in higher education I really struck a chord because we are operating our brightest students are working in campuses which offer really narrow avenues of knowledge. The challenge is very limited. You have engineering, you don't have science or humanities, you don't have those broad university bases…fairly lacking in many other things, I mean science and particularly science suffers in most universities where there is a strong social science or humanities program. We have lived in two different world too long, we can't afford it. I completely agree with the spirit of Yashpal committee's report though operationalizing it in our culture is going to take a long time its not going to be easy. I will give you a copy of it, kind of thing that these consequences of policy which were initiated at that time, soon after independence, largely to do with Nehru's idea of development, role of science and technology in that development, as research and education disciplines and somehow role of the

social sciences came to a stop, one doesn't find as academic disciplines research profiles, what is the purpose. The literature I looked into revealed Nehru's thinking didn't seem have this idea, and as I say it took us fifty years to realize that we can't stop at IITs, we have to have institution in science. It may take us another fifty years to realize we need universities of that high standard. Somehow we gave pride of place to science and technology and missed out to technology, now we realize science is important. Now we realize all branches of knowledge are important and they must develop together.

The Initiative: To push you a little further, given a choice say in an engineering department, would you have a course in philosophy or would you have a course focusing on Heidegger's question concerning technology?

Dr. Ravi Subramaniam: These are practical matters. One knows how much time one has to give even to learn engineering. I have taught in an engineering college for three years. Firstly courses on applied physics, applied mathematics has to be very strong because they are the foundational courses for engineering. Now courses on applied physics and applied mathematics will be strong only if there is a very sound connection with basic theoretical physics and sound mathematics. The foundational courses should develop depth as well as breadth. The foundations are deep because they are broad applications. You have deep complex learnings of mathematics, precisely because that complexity allows you to cover a whole gamut of applications. So it needs reshaping or rethinking of these kinds of courses so that the load on the specific engineering courses is less. Specific engineering courses students has to get familiar with things as they actually work…the other aspect that they come in contact is how to model these various phenomena the working of these devices, what are the standard techniques of these models. Now the modeling aspect is something which can be strengthened before, provided there is a strong emphasis on different kinds of modeling in the applied maths, applied physics kind of courses. They are well related to more foundational theoretical courses. I think the core curriculum has to be restructured if one has to integrate education which allows for some breadth as well as depth. I don't think we have the resources required, this is my guess and I am also talking a little bit from outside. I have not worked for a long time in a very good department in a good institute to understand their philosophy, in fact I was a student rather than a faculty. The role of humanities

and social sciences is not …one thing one will really like is strong high level exposure, coming out of the courses which will happen if you are in a campus where there are exemplary lectures by leading thinkers in the humanities and social scientists. This can be primary modes of interaction, this will really open up people I think to the practical sense, to new ways of looking at the world because very expensive, and almost impractical in our present circumstance to grow departments of very high quality in the social sciences, institutes like IISER or the IITs. But if there was a campus where there were such departments, and students lived and worked in these campuses I think that would have been worthwhile. Courses are very limited in terms of how much they really open you out. if you don't have a basic interest in the course you are doing you are just going to do it to pass the exams and get the grade, which I did in most of my undergraduate courses. The course in the humanities I gained from because I took them up from my own interest. You will have a few students who will come with such orientation. Its good to have a humanities department which can satisfy their needs and interest. I think there is a dividend to be paid off in the long run to society as a whole. But otherwise the students who are going to stay in engineering and science I think exposure outside of courses.

The Initiative: This is the CCS-IISc model. They have not set up a humanities and social science. They have lectures, courses, visitors program. Infact we would like to invite you for seven days. you can spend some time with us. The idea was to open up IISc PhD or MSc students to other methodologies, other ways of approaching the world, other ways of making knowledge.

Dr. Ravi Subramaniam: I think the visitor's program is something new in IIT Bombay. In fact they have resident artists, musicians. Eventually in the long run people working in physics or mathematics might take a deeper interest from their own discipline to music and that can lead to something creative.

The Initiative: That is one of the interesting points that we have been making. Even from physics you can move to mathematics and answer questions, its not that we have to give them a dose of humanities but how to make that possible within the science education space.

Dr. Ravi Subramaniam: I am forgetting the name of this physicist who became very interested in origami, initially it was on the side but then he developed the mathematical theory behind origami, and the fascinating thing is that developing the mathematics fed back into origami. It became possible to develop origami as an art at an unprecedented level. Now the art of origami is so well developed that you can fold any naturally occurring shape. And this has become possible partially because its mathematics is well understood. Once you understand the mathematical principles you can produce and explore variations and then use them in art.

I think the case of music is also like this. Actually some of its history that we know from like its connection with mathematics in Pythagorean tradition, Pythagoras worked with string instrument, studying the physics of string instrument, the ratios of lengths and developed what is known as Pythagorean scale which is a natural scale where the notes are good tone notes, what are called a major scale and they are in integral proportions. Pythagoras was interested in developing a physics of music. How is it that strings that are physical things produce ethnic essence which we respond to and he found numbers …so physics and mathematics have a deep connection with music which we don't understand fully which has been intuitively known and appreciated in the Indian tradition. All the complex rhythm patterns have a certain element of proportionality and mathematics embedded in them and it was only in the last decade or so that people have been exploring the history of Indian mathematics India's connection with … and elements of rhythm and there has been a very good work by Jaynan(?) a mathematicians in the early centuries, developing theories of combinotronics which we were not fully aware of, like the Fibonacci series was known in India as early a8s sixth century, some of the properties were explored it was called it was called the chandashastra. Students of physics and mathematics with a side interest in music begin to see these connections there are scopes for many things to emerge. For the physicist I was talking about, although initially origami was a hobby, he began to use origami techniques in applied physics, in semi-conductors and in packing chips or in gadgets which can be folded into compact shapes put into spacecraft which will open out to specific forms when you put them on a satellite. This is quite a fascinating story what can come out when you try to integrate many things. I remember his name its Robert lank.

The Initiative: What would be your suggestion for the IISER program, given that they have they have mathematics, physics, biology, and chemistry in an integrated way, first two years they have all subjects and only in the third year they choose. We have been told to set up the HSS, and that is the thing we are struggling with, whether we should set up the HSS or some other modes, or the way you put it the philosophical core of the natural sciences, we were thinking along those lines… That would be one interesting way.

Dr. Ravi Subramaniam: Those were Gadamer's words. In the IISER context there are obvious practical…is simply one large university campus probably represented by places like MIT where people are…as Chomsky, it has got physicist, engineers and nobel prize winners, it will take us some time to get there.

The Initiative: Is the university model the only model of learning and all research centres, all science centres, all technology centers, all medical institutions, all management they all have to become universities to sort of answer our integration question?

Dr. Ravi Subramaniam: That's an absolutely valid question. We have to think of different models, I completely agree with you. From the point of view of the student, he or she is hungry for that which broadens his horizon and give some relief and perspective to the intensive engagement to what he or she does. Now in science program, in research program, the experimental components, the course works itself could be stimulating enough to the students. But in the long run when you get a broader range of students with different profiles you will have to give them different things to get them focused an interested. So initially it's a matter of exposure, you give them a taste of something different whether it is in art, or in the humanities or in the social sciences. Once the student gets interested in something you need an opportunity for the student to pursue this concern in depth, so you have to think of some institutional structure which supports this, having done this there is a further step, which is to tie it back to other kinds of thing which are the core strengths in IISER. Probably one is conceptualizing it as going out and then coming back. in IISER there must be channels for this restriction. The restrictions probably provide initial exposure, some kind of mentorship, some kind of student attachment programs might provide a second kind of opportunity. The third level would happen when some

sensitive faculty in IISER itself who are open to for example in the final project that the students do or the post degree work on some project that they do have some extended stay, I don't know what is the curriculum model in IISER. But they could have things of this sort which tie things back, with some wholesome engagement in different kind of activity which is integrated with what they do, they don't feel this schizoid existence of doing one thing in IISER and their heart is elsewhere.

The Initiative: This is one problem which I know from my struggle also. The student finds them split, which way do I go, which stream do I take up: science or humanities. Well in that sense minimizing…whether we can minimize or temper the split.if they continue mathematics with music they can continue, if they do music with mathematics they can continue, its not that they have to abandon one pursue other.

Dr. Ravi Subramaniam: Education is also a process of socialization. Its not merely preparing a student in terms of knowledge and tools. As a undergraduate student in IIT and later as a postgraduate student, …students have concern for values, for social issues, and these are channeled in different ways. There are people who participated in social movements, in students movement, in protest movements, in dissidence. All of these has been a part of education. Its something that shapes your outlook and way of thinking for life. If I work an education and I have a very clear commitment to main stream universal education, its because of the socialization that has been a part of me, that has been provided to me by the institutions I went through I think that is something also very important for places like the IISERs. If you want the students to ultimately internalize the nationalist spirit, the spirit to give back to the society not just their own personal interest. the parts that are there must find expression. This socialization and taking interest in issues of ethics, of justice are very important parts of that phase of education, undergraduate and postgraduate phase. One should think about it or there will be students who are only concerned with their own career.

The Initiative: There is another point that I will bring into the discussion. This is another angle that an education apparatus could make possible.

Dr. Ravi Subramaniam: I think the social science in our country, I am really impressed because they maintain this connection with social movements. Bombay university preserves connection with social movement through people like…I think that's another important thing, the engagement with social issues, issues of justice and wellness. Its important for anybody not just for students in social sciences.

The Initiative: So do you think natural science in our country has been blind to this aspect and failed to train students?

Dr. Ravi Subramaniam: Yes certainly because it's a part of the inherited education system which most natural scientist come through is fairly narrow. It gives exposure only to science. Luckily some of them have been trained in institutions and grown up in conditions which are of a different pattern of socialization. So they might have some sensitivity, but the academic program have never been structured to impart sensitivity, its been narrow and focused and they certainly suffer because of that.

The Initiative: The other question that is coming up is science education in text books, there is a lack of reflection on science as practice, science has laboratory….and science also has the social risk and all sorts of question, sometimes …service is paid to, that science has bombs, you have a catastrophic situation to look at the social, but science as practice component is somehow missed..

Dr. Ravi Subramaniam: There is probably a very broad realization, there are a lot of changes, from the point of view of science education the trends are changing. The society that emerged from colonial rule very class-stratified society, Brahminical form of knowledge and so on, …fortunately in science we have had a strong history of experimental research of very high quality. The great scientists of India have been experimental scientists. Somehow its finding a way now more and more into the curriculum. I would say ---- has played a role in that process. Firstly through the developing of Olympiad movement in physics chemistry and biology which has a very strong laboratory, so the Olympiad students who compete for the Olympiad and participate…and experiments are quite challenging and exiting. Those labs are being developed.

Now in fact HBCSE members are involved in shaping the laboratory curriculum in some of the institutions including the IISER. And other universities also …other than HBCSE some other physics education has taken this up. There is also change in technology which makes it easier and cheaper to set up labs. There is an application of physical apparatus with software which makes the thing exiting, there are many changes underway and we will like to see the impact on students. I was initiated in HBCSE also …undergraduate students getting more into research kind of activity…that's also emerging and I think IISER also have similar arrangement. So thinking has been there, its finding institutional expression…. at some level

The Initiative: Would you end with some word of caution for what we are trying to do at IISERs?

Dr. Ravi Subramaniam: The more I work on education the more I realize it's a complex domain for reflection and for practice. It is quite often a balancing of things, you cannot afford to swing too much in one direction, the pendulum cannot swing too much in one direction. Since it is complex one must keep many perspectives in mind. Understand that students who come to the institutions at an age, at that time, personality, background, values, interests, commitments and the education needs to be sure it keeps these in mind and keep a balance between various aspect and does not swing too much in one direction.

The Initiative: Also somebody who has looked at education. Because we have not looked at education as such, we are just beginning to look at it. One last question and I hear it from some that Indian science is not quality science and there is a lot of lament and sense of crisis in science education in India. Would you just end with your reflection on this? What do you think about it?

Ravi Subramaniam: Of course this is a very big concern and as a huge country, major civilization historically, there is not sufficient level of activity, there is some kind of lack, there could be many reasons for this. One is the commitment of leaders in the fields to creative scientific research. There is a certain boldness and creativity which is needed, which is something the institutions do not train for. So those who, very competent people who occupy

positions of leadership cannot get into that bold mode, take risks and chart new areas. That is one side of the story. Another side of the story is that the foundational preparation is just not enough for the really creative means to occur … that education though rigorous and ….is probably not deep enough even within a discipline. For example we don't have a depth of understanding of history of the great achievements in core sciences. We are very good at details of knowledge but the core concepts I am not sure. The first one I can say ……but in mathematics for example we don't understand the great trends and achievements in mathematics in the nineteenth century that prepared the ground for so much of grounds in physics or the mathematics of the twentieth century which takes it to another level. So the depth of academic preparation is not incorporated, very few premier institutions in the country have the ability to give the students some expertise in these areas. The third reason could be that we draw from too narrow social base. Although we are a huge country the section of the population from which we draw talent is very narrow who though are very high in ability may not be high in modulation and in terms of commitment. So again the culture which selects its talents who may be screwed in ways, which in long term will undermine creative knowledge. This can be another reason. The fourth reason is that there is probably as a postcolonial society we operate personally within several binaries we live out plot which consist of several binaries like traditional-modern, villages and superstitions on one side and scientific and rational on the other. We are still to come to terms with these in some creative way. we have to look at depth at our culture which are acceptable choice for consistent thinking person who seeks some philosophical coherence and find some roots in culture…we still have not found that depth of understanding. it will happen when we understand our own culture better. We have neglected and ignored the understanding of our own culture and fortunately its not lost and probably it can provide some depth.

The Initiative: Do you think its true there is a crisis in science education?

Dr. Ravi Subramaniam: I definitely think so. In quantitative terms the scientific output has not been very high. In qualitative terms, in terms of impact that a scientific work makes in any field, particularly there is no reason why we don't have leadership. it will take some time, I don't know how these things really work, how did Japan become a major country in research and science or technology, what is the contribution of China, what is the contribution of Brazil who have the

numbers to back on. Their scientific output is way higher than India; what is their impact on shaping scientific research.

INTERVIEW WITH DR. ASHA ACHUTAN (CCS-IISc)

August 31, 2010

The Initiative: Can you tell us about your journey? Of moving from the natural sciences to the social sciences and then back to science?

Dr Asha Achutan: Well first, I'd like to say that it was not a planned journey. This is going to be retrospective construction. I didn't step out of science because I was dissatisfied with science per se but a series of other life events led to me where I am today. In my case this was the scenario: We were on campus where we were learning medicine in the classrooms and our political awareness was in the corridors. At one level there was an indifferent connection between the two. There wasn't really any clashing between the two except in terms of time; for instance, when we had to cut classes to attend a meeting. There was no direct engagement. This was in the 80s, so it carries those contexts with us.

The clash between our interests remained an issue of time until '92.We were all finishing our MBBS at this time. What hit a lot of us at that time was the demolition of the Babri Masjid. We all still remember the day it happened and the manner in which the news arrived and we watched in shocked disbelief, the whole act being filmed and then saw directly the repercussions that came from the event. I think that did something to us. I remember that it was a period of confusion. There was no confusion between politics and epistemology, but I remember in the wake of the event going to the National Library and picking up a card and then for the next 1 ½ years we read. At the same time we were doing other things- there was some mobilization regarding the whole Babri Masjid event. For instance we started having week long events every year around December 6th whether in the form of talks or poster-making. It was more involved and informal in comparison to what we do right now but still very intense. I would like to stress though, that the pitch was still not very high- it might have been at the level of emotion but we had not consolidated any of these feelings into an anti-establishment or anti-state movement.

But 1 ½ years of reading did do something to us. I discovered *Imagined Communities* for the first time in the National Library and we didn't know what a bombshell we had discovered. I also remember picking up a book by Bipin Chandra, one of the earliest on communalism in India. We started reading more and more on communalism and making connections with nationalism. By this time though, a shift did occur where I told myself that science would be my profession and my passion would be something else. This something else was not clear however. And one thing that I was sure of was that I would not do Gender. And this is mainly because women are expected to do Gender. It's the same reason that in medicine I decided not to do gynecology.

In '99 we started the journal of critical theory *from the margins*. So a shift that happened over here was that we moved from thinking politics on the street to recognizing the need for theoretical activity and that was a reaction to the Marxist scenario that was playing around us. We were part of a group that very categorically said that we do not want allegiance to a national party. That was our campus political scenario. And then began this dissatisfaction with the way politics was being done. That led to some kind of consolidation of movement and we also began reading towards that direction. This became my passion. And Gender became a big part of this. I ended up thinking differently.

I don't think in my case though defection or dissent from science ever happened. What I did was that in 2001 when I started the M.phil course I was still practicing medicine. So then it became difficult. It became a two boats scenario. Again it was because of time. Also, at that point the intellectual involvement was greater in gender. At that point, though it had probably been brewing for quite a while, some non science feelings emerged. This was also the time we began linking science to the problems of modernity and development. We began to see science as the underlying ideological position for modernity. I won't say that we were entirely out of the conspiracy theory notion that science is responsible, or science is hegemonic. But I must add that at least for myself what we meant by hegemony was not clear. Science was the all powerful patriarch. Whatever theories of exclusion we began thinking of (theories we had thought of) would not fit the bill. This was definitely the beginning but I would still say that the movement out of medicine was not a defection. I justified it as such to my medical fiends who questioned me. The thing is with any other discipline, rather profession you leave and it's okay but in this

instance the common accusation that would come my way was “you are a healer and you are abandoning your responsibility to society” and the other is that one has wasted a seat for someone didn’t get it because of you. So this is a profession that has so many moral over tones that there was a lot of pressure. This was also the time I had finished my M.Phil. I had done my M.Phil under a lot of strain. So it was a time problem as well as the sense that I was not giving my all to my medical profession. I felt I was slipping up there. So then I worked on the possibility of a PhD. There were no fellowships however for social science studies then and I needed to think of ways to support myself. I heard about the CSCS fellowship. So I applied and got through.

I still remember the day I put in my resignation and was having my last lunch with them. There was no animosity while leaving though, they were sad to see me go but still they were telling me that I was doing the wrong thing. At that time I justified it by saying medicine has a problem. But I could not make that argument stick. Partly because that was the audience but partly also because I did not have arguments properly thought out.

The problem with science came up only then... when we started seeing a problem between science and life or science and politics, etc. Then when I did my PhD there were other questions that did come up. In my personal journey, I would say that there has been a return to science for me. This has happened because partly one has stepped far enough away. So one has achieved a certain measure of distance and one does not feel caught within its clutches. Partly it was also because my own social science and cultural studies training in my PhD helped me look back on science as a resource for picking up ideas.

The Initiative: What was your experience learning science as a student?

Dr Asha Achutan: Now I am not sure but the one thing I do know is that there are different pressures. I think research activity has changed in that the notion of the field has changed. Researchers no longer go into the field. There is now modeling in the lab. Even civil engineers are simulating in the lab. They have different codes designed and then they will do one field

visit. So the shift from representation to simulation has happened. I think that when I learnt science, it was done very passively. There was no reflection involved. We learnt that for anatomy we would have to do dissection. It was all about the 'how'. There was not a single 'why' question. I think that's probably how state universities still teach. Over here (in IISc), it is different but it is the exception. Because we live in the exception, we think that there has been a great shift but really I don't think that has happened. There is a lot of cross-talk though. You cannot come out a small university and have your head in the sand and have it remain that way. To not be challenged is just not possible anymore. The challenge is happening more now than at that time. Lives have changed... you have to move across institutions. In order to be a valid teacher, you are bound to be challenged. You can't get by without asking yourself these questions.

The Initiative: So according to you how has the young scientist changed in relation to society?

Dr Asha Achutan: The scientist dabbling in society is no longer a singular activity. Earlier it was the socialist welfare state impulse. Now it is no longer that; it is the democratic labour impulse. I would say that there are a lot of people who feel responsible or feel being ethically bound.

The Initiative: Having gone through these different stages of contemplation, what would you say science is?

Dr Asha Achutan: The immediate thing that strikes me is that it is a far smaller monster than what I originally thought it to be. Having been placed in a science institution like IISC, which is a pure research institute -unlike the IITs or IIMs- where the big picture of science is much more clearer, where the connections are much more visible, where the notion of the all powerful science is a reality, is that it has the image of the scientist as the ascetic. The ascetic who lives in a hostel with no water, to spending hours over a particular object in the lab... it is this image of the scientist that resides over here in IISC. This is the older image of the scientist. This is the image that does not have immediate connections with power. It’s not that I got conned by the

image- for instance you do know that there is heterogeneity to this picture. Heterogeneity need not deny power; it does mean that there are cracks in the picture and that there are good things about it too. This definitely helped in stepping out of the conspiracy theory, though in a sense it had already occurred in a theoretical frame. The difference is that over here you really experienced the cracks and the good things. I would now say that science is a form of knowledge and this is obviously a social science understanding of it that is reflexive. It is not as vague as we would like to make it be. But this is a good thing. Otherwise it becomes very science-centric. In social science sometimes we become so science-centric we can't think outside of are we building a good enough image of science or what are the ways out of it?

The Initiative: What would you say are the problems of science coming from your previous understanding of it to now how you view it?

Dr Asha Achutan: I will give you a very cryptic answer: it is the right answer according to me but it may need more development. I think we were used to thinking about science as hegemonic and science as all powerful and all pervasive. Basically, the way we saw it science was the problem. In doing so, we had this mental image of institutions and state institutions and certain actors and powerful individuals that was a very empirical picture. Furthermore, it is the picture of the hegemonic that I would say now is not accurate. One needs a proper picture of hegemony before you can talk about state or scientific hegemony. Now I would say that the shift has been that say in India you need to think about the institutions the actors and the texts of science so is there such a thing as big science? The debate has been about whether science is science with a capital or a small "s". Is it necessary to move from the biggest to the smallest? Big or small, there is a definite relationship between the texts of science, the language or the way it is written, the way powerful institutions operate and the way actors are encouraged to operate within that institution. This connection needs to be made in order to understand the hegemony of science. It's not like one particular institution is responsible or that one set of individuals are forming a clique and *that* is how the hegemony is being developed. There is an inextricable connection between the text books, institutions and the actors which is not intentional in that sense of the word. And this is why you will find that the hegemonic reacts most violently when you accuse

him of being hegemonic. This is because the hegemonic does not operate through intention or a conscious apparatus alone.

The Initiative: How would you identify yourself? Would you say you are a scientist or a critic of science or a social scientist or would you not like to label yourself?

Dr Asha Achutan: Well, immediately all those labels evoke some form of cringing. I remember while doing my PhD that I thought of myself as being a 'Physician Feminist'. So there was that attempt at straddling the two: science and feminism. Is feminism is better accommodated under the label of social science? At that point the leaning was more towards the social sciences and one saw oneself as a critic of the natural sciences. The personal journey has made sure that the labeling and allegiances have shifted. I think the greater effect is in the labeling. The moment someone calls me a social scientist immediately I think of all the bad work in the social sciences and I don't want to be associated with it. Then when some one calls me a natural scientists I don't even feel anything… no attachment, you see. The attachment is more towards feminism and then social science. The way I see feminism is that it is the beginning of interdisciplinarity and I know this is a tall claim. It encouraged defection from disciplines, so in that sense it was an infant notion of interdisciplinarity. But it was what made it possible. For instance, there was no NET in women's studies. Now of course there is, but at that time it did help break some of those barriers.

The Initiative: There are two questions here: One how does integration happen in a person? And then reflecting on the CCS experiment of having these courses, what will you say are some of the problems the course has thrown to you? Where do you see the promise or the problem of interdisciplinarity lies?

Dr Asha Achutan: Sometimes I wonder if we are asking more of a word (integration or interdisciplinarity) than it can give us. This is an immediate reaction. It's also a reaction good to keep in mind. Again, let it not become a label… it becomes evacuated from its meaning. Partly because I am here, there is a sense of saturation.

To answer your first question I would like to refer to a workshop that had been done on interdisciplinarity a while back where Anjan Chakravarthy made a provocative presentation in which he focused on the personality of the integrated teacher. He, for instance, made it seem as if it were possible only at the level of a personal journey. So then it raised the question 'Does it depend on the teacher the entire time?' And in that case, what hope can we ever have of taking it to the level of the institution or have an academic movement called interdisciplinarity? But I think the value of that statement was the knowledge: that we *all* arrive at interdisciplinarity at the level of the personal journey (whether we need to call it that, I'm not sure). But this attitude to integration is as personal as it is academic. Therefore it needs to be a double movement; in the sense that the social is inside the individual. So the personal journey is crucial.

But to jump from that to the course (*Production of Knowledge in Natural and Social Sciences*), I have to say that all of these thoughts have come out of the course. I think the 2006 course was the best. It was partly ahead of its time. It was engaging with thematic debates across disciplines. It was already throwing open a notion of interdisciplinarity that had not been experimented with, at least in this setting. The science institutions have been the first to do multi-disciplinarity approaches, whether it is nano–technology, bio-technology, etc. Multi-disciplinarity approaches have been rife and there has been some confusion as to the categories of multi-disciplinarity and interdisciplinarity. So for the first time it threw open this clarification that we are not talking about multi-disciplinarity. Furthermore it made disciplinary walls porous, partly by looking at the methodological assumptions across disciplines and the problems across disciplines. For instance, positivism is not a problem of science alone. It is a problem across physics and history, psychology etc. So the sharing of problems in methodology and history helped a lot. It is not easy to make a critique of science; these problems stem across disciplinary borders. The problem is positivism, not physics. If physics were to go away, there would still be sociology. So I think that first course really helped in this manner. We also began talking about integration at this point, though the integrated science initiative was not born yet.

One thing that happened was that something came into visibility. It happened when this problem of classroom integration came up. We had a bunch of social science and natural science students

together. There was a fair distribution between the two. It basically started with *The Two Cultures Debate* (C. P. Snow) where Tejaswini Niranjana made the point that there are no two cultures because the problem is spread across disciplines but what happened was that it ended up consolidating the two cultures debate in a caricatured sense because here were these two kinds of students who were trained differently and made to think that they came from two different worlds. Also, they were trained to be critical of the other in a very superficial sense. So we ended up having debates on objectivity versus subjectivity and positivist versus experience as the focus of our debates. Feedback on the sessions showed me that we need to be clearer about our concepts. The imagined ideas we had about disciplines had to be dispelled. Rather the focus should be on what are we talking about when we say interdisciplinarity? The other issue that came up was that the classroom integration problem was not going to go away. So unless we talk about it in more formal ways, personal journeys will only encourage defection from the disciplines. It's not going to help you build something. So I think I learnt the most from that course: both the possibilities and the promise of interdisciplinarity.

The second course was more a historical overview. The first course addressed the sharp relief in contrast between the traditional view of knowledge as a mirror of reality and the post foucaultian notions of knowledge. The second course focused more on the disciplinary canons that exist. I feel like we have done enough analysis. No more dwelling on the word interdisciplinarity. We now need to do things. Even now, people are already doing things differently… possibly due to their own personal journeys. For instance people are teaching differently. Someone like Ragavendra Gadagkar is teaching differently. He is not following the orthodox ways. Even Prof. Chanakaya is not longer teaching Sustainable Development in the old mode. There are people who are scattered all over the universe doing things differently. My point is that there should be some way of having their methods being put up as exemplars of teaching. In this way, one is formalizing the bringing of the corridor into the classroom. So it's not that one teacher is different and this may have implications for classroom integration. So hopefully this will be different and not step back into orthodox teaching modes. RG does this not by giving up on the descriptive component of research and theory building but he also brings in the question of the why.

For example, Sanil V made an interesting point about how the social scientist needs to be reflexive. I feel that in being critical of science we may have withdrawn from cognitive activity. This is the ambition I have for the course. Again though there is a problem of mutli-instructorship. I think it is working and in order for it to move forward it needs to be a collaborative effort. But I think we are stuck somewhere in trying to move from collaboration to sociality in teaching. In collaboration there is a sharing of teaching product. Already there is a level of difficulty there. You can share insights but only that much. But we need to articulate the problem together because when we do that we articulate the problem differently. If we do a fourth course then multi-instructorship will have to be framed differently… that it is a collective framing of a problem.

The Initiative: In our initiative we are trying to take a model to the classroom. But from what you have said, perhaps one should start with the teachers? I mean the recognition is that the teachers are doing it, not the students.

Dr Asha Achutan: I have a problem with the whole teacher training model. I mean you need to do the classroom experiment because no amount of training will prepare you for what will happen in the classroom. You need a far more deep engagement amongst teachers. So you do need a teacher training model but you also need to take it to the classroom.

The Initiative: Okay so then the experiment is done in the classroom for whose benefit? The teacher or the student?

Dr Asha Achutan: Both. This applies if you think of learning as a collective activity. I mean, there has been a shift in how even PhD lectures are being taught, for example in CSCS. It is a collaborative activity. Learning in the classroom will become a collective activity through this.

The Initiative: What would be your recommendation for us? Since we are trying this out in IISER and it would be good to get some insights.

Dr Asha Achutan: It would depend largely on the context. I think that we have a very small pool of people who have an idea of what's going on. Therefore, rather than contribute carelessly to sets of experiments all over the country I think it would be better if we were to take our people there. This model of training them will be a life-long exercise. Of course I'm not saying it can't be done but for it to happen we need to know them. And we don't even know them. It's not like I don't agree with the idea that we need to develop some kind of model there. But I think we need to first there needs to be a value for learning across contexts. Otherwise there is nothing such as general. Everything is local, microscopic and contextual. Learning across contexts is crucial. That way I think learning from the small pool of people would be better.

The Initiative: Would this be the 'outsourcing model'?

Dr Asha Achutan: Yes we could call it that. But it is different from the American sense because it would not be someone going out in the cold. I cannot go to an institution without learning about the context there and started a course. Or if I start a course I would have to do it in the collective sense and I would have to make that clear to the students.

The Initiative: Would the connection continue or will there be some point when you stop exporting or outsourcing to them?

Dr Asha Achutan: No, the connection will have to continue. Otherwise it will come down to divides. That's not what we are working towards. We have to connect people. This is a world where the context is important; the idea that something works here and doesn't work somewhere else. This a battle one has encountered in feminism. There can be a general model without it being a universalist model. The problem is when a general model becomes a universal one. We know that universalism is always anchored to one particular context. Is it then to say that there is no possibility of generalization?

The Initiative: Professor Gagadgkar has made the point that when you reframe a problem in the language of a person who does not belong to your discipline there is a fundamental revisiting of your own discipline. So we would like to ask whether through the revisiting of science in your life now, has there been a re-visioning of social science for you?

Dr Asha Achutan: It did. I think Professor Gadagkar has made an important point about translation across incommensurable barriers. We tend to think that translation can happen only where there are commonalities. But translation can happen across incommensurable paradigms. Translation is required where there are paradigms that seem incompatible. Part of the reason why social scientists will deny being a part of their discipline is because when they started with a critique of science and did a thorough and objective enquiry into the science they find that the critique was wrong. So what is the basis of critique then? Because social science has certain theories of exclusion… the hegemonic for instance. We are critiquing dominant frames and we don't have any idea about what we mean by the hegemonic and we don't have clear theories of exclusion. These may sound like tall orders but one needs to have them nevertheless. One needs to clarify what you mean and then to communicate this. The value of science has been that it has forced you to clarify what you are saying. That engagement has made a lot of social scientists look back on the methodology of their critique, at least that is what happened to me. So placed in a pure research institution and having some form of the conspiracy theory of science all helped me when I reflected on them. I recognized that I was doing something wrong that even though I was trained to say, detect adrocentrism, I wasn't really doing it. I realized had to let go where I was doing things wrong.

Self-reflexivity has reached a point where you want to do things differently. I don't want to for instance step out of feminism but I do want t try and do it differently. Not doing it a non option for me-and not a useful one at that.

The Initiative: This brings up the whole debate of whether one can stay within a discipline or system and still critique it.

Dr Asha Achutan: Yes, also the most vital activity of interdisciplinarity is within the discipline. I mean we all start with ideas of how a discipline should be done for instance, with feminism there were some typical issues that one would consider important. The moment feminism started calling itself feminism and wanted to step away from allegiance to affiliated organisations -the issues that were spelt out were dowry, rape, domestic violence etc. - these have become canonical. If you suddenly want to talk about poverty, you would need to legitimize it within the cannon of feminism. We all have a fixed picture of how we think feminism should work. My question is why should it be like that?

So the question is then, am I going to be able to change this? And change, not because we want to but change because it's not helping me make a good critique. It is important here to acknowledge that the critique would have to give new knowledge. The work of interdisciplinarity will have to be primarily within the discipline. This is the primary objective of the CCS courses. My hope is that people will not come here and say "I was trained as an Economist but I'm not an economist anymore" That requires less courage than saying "I was trained in economics and I want to do it differently and I will have the courage to take it to the classroom. The people in the classroom will go to other class and then there will be osmosis. That is crucial. It also then goes on to prepare a fresh generation of researchers.

The Initiative: What is your take on the words interdisciplinarity and integration? Are they the same thing or are they different?

Dr Asha Achutan: I think that integration has more of a sense of activity - institutional activity than interdisciplinarity. Interdisciplinarity is more a reflexive form of activity within a discipline. Integration has been around for a long time. It may not have been under this label. From the time Higher Education began, since the idea of good citizens came up. My question is if we can make the interdisciplinarity the basis for integration? The kind of interdisciplinarity I am talking about - use that as the basis for integration. First of all there won't be a collapsing of disciplines; one will not speak about defection from disciplines. It is not useful anymore to talk about

interdisciplinarity like this. Let us think further than this. This small group is working this way instead of thinking of multi-disciplinarity as the basis.

The Initiative: You seem to have redefined interdisciplinarity as reflexive rather than just action.

Dr Asha Achutan: Yes, I would say its activity is reflected in the classroom.

The Initiative: Just to clarify, when you say interdisciplinary research one seems to be saying the action is interdisciplinary.

Dr Asha Achutan: That I agree with. Seeing the problem collectively-different from the canonical ways of looking at the problem then that is activity. But it's not easy here to separate the theory from the action. There is going to be the same cross fertilisation between hypothesis and action as before. Let's not get into the theory activity debate; here that is one thing that we have been trying to move past. It is useless to try and separate the activity from the theory. I think the question needn't be asked anymore: The question of the primacy of activity over theory is an old Marxist one that I don't think we need to address over and over again.

The Initiative: Could it be said then that interdisciplinarity is the essence of integration and that integration takes forward the work of interdisciplinarity?

Dr Asha Achutan: Yes, it takes forward the idea and then puts them to experiment. That way there is also cross-fertilisation involved. Integration is far more active.