to select the first set of Ph.D. students in Philosophy in IIT K. He took me along. I was amazed that when he had a million things seeking his attention in Institution building, he gave enough importance to students' selection. This was the first of several surprises to me about the wonderful person that Dr. Kelkar is.

I never taught before and hence I had to spend a great deal of time preparing for each one-hour class. The students are brilliant and this adds to the challenge.

The faculty became involved in all aspects of institution building and operation. For example, I was made Chairman of Equipment Committee with several members including one from Kanpur Indo-American Program (KIAP). KIAP is a consortium of nine leading universities in the US to help develop IITK. In addition, US Government provided about $ 10 million for purchase of equipment, to be dealt with by the Equipment Committee. Some of the equipment was for the teaching labs but more of it was for research. In order to make specialized, expensive equipment available to all faculty members, it was placed in Central laboratories instead of departmental laboratories. For example, IITK had the first computer in any educational institution in India and it was a central facility.

As soon as I joined, I was made the Head of the Metallurgical Engineering Dept. Five months after I joined, I was promoted as a full Professor. When Dr. Kelkar created and appointed the first two Deans (one for Faculties and the other for Research & Development), it was a new initiative among the IITs. I was appointed the first Dean of Faculties, with responsibility to hire quality faculty for each department and to look after their needs. As Dean of Faculties from 1966 to 1972, I had played a key role in adding over 200 faculty members to IITK, a large number of them from abroad, mostly USA. For this purpose, I used to make trips to US to meet potential candidates and their referees and to provide information about IITK to them.

As Dean of Faculties, I realized that most of our faculty are trained abroad and have little or no exposure to Indian industry, its level of development, nature of its problems etc. As a solution to these lacunae, a novel programme, High Level Summer Opportunities for Faculty in Industry, was conceived and developed. I went around to various companies to explain the goals of this Programme, which is a win-win for all concerned and then sought some problems the Company would like to have a fresh look at and come up with implementable solutions. Thus, I collected a set of industrial problems, matched them with the background and interests of the faculty and if the identified faculty agrees, his (or her) name is proposed to the Company. The Company then sends an offer to the concerned faculty member. The work gets done, and a report is presented to the Company. Nearly half of the Engineering faculty participated once or more in this Programme in the first few years. This has influenced the teaching material of such faculty and also the projects they assign to students. Many Companies participated in this programme in successive years.

Another major contribution of mine to IITK and Indian academia at large is the introduction of Materials Science as a discipline for teaching and research. It started with a 10-day conference on Materials Science Education at IITK in 1966 with many teachers and also engineers from industry as participants. Three prominent materials science educators from the US had attended. Now Materials Science appears in the curriculum of all engineering colleges in India. I set up an inter-disciplinary programme in Materials Science leading to M.Tech and Ph.D. degrees where the students as well as faculty are drawn from many engineering and science disciplines. This was followed by creating an Advanced Centre for Materials Science to house sophisticated equipment for materials research as a Central facility.

In the early years of IITK, there were not many Ph.D. students, particularly in the Engineering disciplines. Therefore, nearly all the research was carried out by B.Tech and M.Tech students. But the brightness of these students ensured that the quality of research was good and the results of such

work is published in leading international journals. This helped the B.Tech students to get into the best engineering schools in the U.S.

Engineering colleges in India, by and large, use text books written by well-known authors abroad, but reprinted as Indian or Asian editions, and sold at affordable prices. In the early stages itself, IIT K faculty undertook to write text books. This effort was assisted by creating a textbook cell with typists, draftsmen etc. As a pioneer in Materials Science Education in India. I undertook and wrote "Experiments in Materials Science", together with four of my young colleagues. This book, in cyclostyled form, was used in the one-month summer courses for engineering teachers under the Quality Improvement Programme of the Government of India. The book was published by McGraw Hill Publishing Co. as submitted and with no alterations. It has been used at all leading Universities in the US. Simultaneously, it was brought out by Tata Mc.Graw Hill in India, with support from National Book Trust to market at a lower price. It was soon translated into Portuguese for the South American students. This was the first of 10 books I wrote or edited.

Because of my being away in US from 1951 to 1963, I was practically an unknown person in academic and professional circles in India. However, soon after joining IITK, I was called upon to participate in a number of high level national and international activities, possibly due to the reputation of IITK rubbing off on me. Examples are: the first Science and Engineering Research Council (SERC) of Department of Science and Technology; the first Committee of the Electronics Commission; Indo-US sub-commission on Science and Technology with six members from each country to identify areas of common interest to be carried out by experts in both countries. For example, in the first SERC, there were 2 members from academia out of a total 8 and they were Prof C.N.R. Rao and me, both from IITK. The Working Group chaired by me in the Electronics Commission recommended establishing Central Electronics Ltd., and I had to present it to the Committee of Secretaries and convince them, which approved it and the company came into existence. In the Indo-US Sub-commission on S&T, I was the only non-government member. Once when the sub-commission was meeting in Delhi, Prime Minister Indira Gandhi wanted us to meet her and report the progress of our work. When the Regional Engineering Colleges were completing their first decade, a committee to examine their progress and future directions was appointed, with me as a Member. The Committee made Bharat Darshan visiting all the RECs from Srinagar to Trichy and made recommendations, which were accepted by the Government.

I was also nominated as a Member of Board of Hindustan Zinc Ltd and UP Electronics Corporation, which proved to be a very interesting experience for me.

ANOTHER TRANSITION

By 1981, another transition was surfacing. Since my three children, for whose upbringing in India we shifted from US to India in 1963, have all got their degrees and returned to the US, I suggested to my wife that we also should go back. She was not in favour of it.

At that time, Mr. F. C. Kohli of Tata Consultancy Services, invited me to meet him in Bombay. We had known each other, since Mr. Kohli was actively involved in the development of IITK through his participation in faculty selections, setting up the computer center and taking a number of faculty during summers into TCS. He briefly outlined to me his idea of an R&D Centre in the private domain to carry out meaningful R&D for Indian needs. He mentioned that he discussed this idea with Professors at the University of Waterloo in Canada. He wanted me to participate in this idea. This is the beginning of the next transition in this engineer's career.

BIRTH OF TRDDC

After the initial discussion with Mr. F. C. Kohli, a team of 3 professors and Deans from University of Waterloo visited India to meet Government officials, business leaders and Tata Management and then submitted a report. I was involved in these discussions. Then Prof. Norman Dahl of MIT was commissioned to prepare a report on private R&D institutions in the US and he covered four of them, following which he visited India for discussions with the Tata Management. I was fully involved in these discussions. There were consultations with the Indian Government at a high level. The Tata people who fully participated in these discussions in 1981 were Mr. J.R.D. Tata, Mr. Nani Palkhivala and Mr. F. C. Kohli. Then I was asked to prepare a final document on the goals, location and modus operandi of the proposed R&D institution. I prepared such a document which was discussed and approved. Since, I was still inclined to shift to US, my wife was persuaded by Tata management about my role. The rest is history.

Thus, Tata Research Development & Design Centre (TRDDC) was born in Pune in 1981 with me as the Founder-Director. The word "Design" was added at Mr. Kohli's insistence, since research and development are incomplete unless it assumes a form through "Design".

The mission of TRDDC is "to use the existing knowledge for the benefit of our industry and our people", in the words of Mr. J. R. D. Tata. Translating this statement into reality was the challenge before me. The tasks undertaken were based on the stated needs of the end user. This required establishing communication with the beneficiaries of our work and develop a partnership relation. The quality of work has to be the best possible which translates into using the best advances in science and technology. For this to happen, one has to have people with a deep understanding of their subject and willing to put in the hard, dedicated work needed to get the desired end results.

The best trained and motivated young people from abroad as well as India were recruited and given maximum freedom to accomplish the best results. Problems to tackle were arrived at by discussions with the end users - Tata Consultancy Services for software and Computer science areas and industries in the TATA group and other private and public-sector companies for others. There were projects funded by Government departments as well as international collaboration projects. The benefits that accrued are new products, improved productivity and reduced energy consumption. A number of patents and published papers in leading journals (many with joint authorship with the beneficiary company) are additional outputs. Based on their work in TRDDC, many people received recognition through election to the prestigious professional bodies, academies here and abroad, awards, publications in leading journals, etc. For example, the benefits which accrued to the beneficiary company were such, that the Chairman of a company included the contribution of TRDDC in his annual report to the shareholders!

As examples of use of science and technology for the benefit of our people (as mentioned in the mission statement), one might cite a low cost, very efficient, well-engineered water filter based on rice husk ash, for the rural people. Another example is low cost decentralized Bio-gas plants using a wide variety of agro-industrial wastes while achieving a high rate of bio gas production by employing specially developed, highly efficient microorganisms.

Some of the other unique features of TRDDC which added to the competent human resources of India are: a number of researchers were encouraged to receive their Ph.D. degrees in India and abroad; a number of faculty from Indian educational institutions served as Consultants on the industrial problems pursued by TRDDC; a number of academics from abroad spent their sabbaticals of a few months to one year at TRDDC.

My gratification is that a wonderful mission statement could be converted into reality with tangible, heartwarming results. The close interactions in accomplishing this with three wonderful mentors – Mr. J R D Tata, Mr. Nani Palkhiwala and Mr. F. C. Kohli – is my eternal memory and reward. For

example, what amazed me about my interactions with Mr. J.R.D. Tata and what I learnt from them was: Considering that he is the Head of over 100 companies, his humility is unbelievable. The undivided attention he gives you when you are discussing something is incredible. The sound advice he gives you based on his vast experience floors you.

SUMMARY

What are the main ideas or leads stand out from this engineer's mind journey. Clearly, a person's success and contribution depends mostly on one's clarity of mind and dedication to quality of work than on one's family limitations. One should always seek and grab opportunities, the more demanding the better. Interacting with young students and colleagues to enable them to reach greater heights is one of the most gratifying satisfactions. Learning from your mentors and mentoring the next generation of achievers is an important goal and contribution. Institution building calls for an open mind, cooperation of all involved, nurturing values, dedication to best quality and meeting or exceeding targets. Value of service to society and of learning takes precedence over monthly income. The latter is likely to follow. Building partnerships is always more fruitful then going solo. Similarly, multi-disciplinarity is the need of the hour than limited expertise.

Lastly, I am grateful for the opportunities available to me, and the wonderful mentors that groomed me and to my family.

THE TALE OF AN ENGINEER TEACHER

Ranjit Kumar Ray

The steamer was jam-packed. Starting from Chandpur it was going to Goalanda, a small river-port on the other side of the Meghna river. The river was very wide at that point, looked like almost a sea. I, along with my parents, a younger brother and a sister were migrating from our house in Comilla town (in erstwhile East Pakistan) to the newly independent India. For a boy of slightly above five years of age, it was quite a traumatic experience.

I was so fond of our house in Comilla. It was a bungalow with gardens all around. My father, with the help of a domestic hand, planted a number of saplings, of mango, jamun and jackfruit. He used to tell my mother that we will have to wait for at least two to three years before we can eat the first fruit from those trees. My mother used to have a small vegetable garden, close to the kitchen. In one of the rooms I had a small desk and chair of my own in one corner, close to a big window. That was my study. There were no play-schools or kindergartens in those days, and so I studied at home. Of course, most of the time during the day, I was playing on my own, as there were hardly any other children of my age in the neighborhood and my siblings were too small. The road in front of our house led to the Ishwar Pathshala, a high school, a few hundred yards away. I later came to know from my father that this was a very renowned school in undivided Bengal. Every morning after breakfast I used to cross the road to the other side and sit down below a big jamun tree to run my own school with invisible students, till the time my mother called me home for lunch. What a wonderful time it was!

We had to leave all our possessions behind and my father could bring only two big suitcases, filled with mostly our clothes and my mother's little jewelry, on board the steamer. At that time, I did not know the reason for our leaving the house so suddenly, but later when we were somewhat settled in independent India my parents gave me sufficient hint to make me understand that we were indeed very lucky to cross over to India alive, which many of our near and dear ones could not make. I became aware of the partition in a very rude way.

After living in two or three different locations on this side of the border for a little over two years, we finally settled down at Howrah, a satellite town of Calcutta, but on the other side of the Ganges. My schooling began here in the Howrah Zilla School, a Government school which started as early as 1845. I passed my School Final examination in 1958, standing 3rd in merit in the West Bengal School Board. When I look back, those were possibly the best years of my life. We had excellent teachers, who not only taught us various subjects, but shaped our character too. I would like to pay my respectful homage to all my teachers through this article. My eyes are filled with tears when I think of how much they gave us for so little they got from society. Where are those teachers now-a-days!

I was the eldest of the five siblings and both my parents used to keep a close eye on how I was progressing with my studies. They always used to tell me that if I were good in studies, my younger brothers and sisters would follow suit. I myself also became quite aware that financially we were not that well off as

in Comilla, and life had suddenly become rather tough and difficult. The only way we could improve our lot was by studying really hard. I think that was the motivation that made me a hard-working person throughout my life. I would like to convey to my late parents, through this article, how much indebted to them I am for guiding me through all the trials and tribulations of my life.

My father, who was in Government service, cherished the ambition that his eldest son should work hard to be a member of the Indian Administrative Services. When I was in the seventh standard in school, he called me one day and told me how the administration was run in government departments and what a useful and honorable job the IAS officers performed. He even introduced me to his departmental Secretary, Mr. Ashok Mitra, who later became the Secretary in the Ministry of Information and broadcasting under Mrs. Indira Gandhi. My father's influence worked on me and I started making up my mind to try to become an administrative officer when I grew up. My ideas, however, started changing after I joined the Presidency College in Calcutta to do my Intermediate Science course (equivalent to the Higher Secondary course these days). It was while in Presidency College that I started realizing that administration was really not my cup of tea. Rather, I was drawn to the study of Physics and wondered if it would be a better idea to take up teaching and research in Physics as a career. A chance visit to the Bengal Engineering College (now IIEST Shibpur) on my way to the Indian Botanic Gardens, also kindled in me a possible career option in engineering. I mustered enough courage to tell my father that I was not interested in IAS, rather I would like to pursue a career in either science or engineering. He was a little bit sad, but told me that I was free to choose my profession. Since the family was going through economic hardship for obvious reasons, I decided that I would like to pursue a career in engineering, which came with more or less assured jobs those days.

I sat for the West Bengal JEE and also IIT JEE (there was just one IIT then, the one in Kharagpur) and made it to the list of successful candidates in both. It was a friend of my father, Late Professor SS Boral, Professor of Physics and Tele-Communication Engineering at BE College, who had advised me to opt for Metallurgical Engineering as the desired course of study. He told me, after I had a long discussion with him, that in this branch science and engineering are so inter-mixed that my passion for science and engineering will be satisfied simultaneously. He cited the case of Late Professor GP Chatterjee (once upon a time, Head of Metallurgy Department in BE College) who did two Ph.Ds simultaneously, in Physics and in Metallurgy, from the University of Pittsburgh, USA. At the same time, Professor Boral assured my father that I should get a very good job after graduating in Metallurgy since Hindustan Steel (now SAIL) was putting up a number of integrated steel plants throughout the country and that there were only a very few metallurgists available, since this discipline was rather new in India. I opted for the Metallurgy course in BE College, which was then more than 100 years old, rather than going to the very new IIT Kharagpur.

BE College in those days was a first-rate technical institution with a team of highly qualified and competent teachers. The college was a partner with eleven other American universities under the Technical Co-operation Mission (TCM) program. Under this scheme, eminent American Professors used to visit BE College for limited periods of time to teach and to help in guiding research. As a reciprocal measure, BE College teachers of high caliber could visit those American universities to pursue higher degrees. I spent a wonderful four-year period in the Metallurgy Department, first learning the basic sciences and elements of the engineering profession in the first two years, followed by specialized Metallurgy courses in the remaining period. By the time I was in the fourth and final year of study, I knew perfectly what I would like to do for a job, once I finished my studies. I wanted to become a teacher and researcher in Metallurgical Engineering, for sure. It was while executing my Bachelor of Engineering thesis, I had a first- hand experience of what research was like. My teacher and thesis advisor, Late Professor AK Seal was very much instrumental to introduce me to the wonderful world of research. One

day he called me to his office to tell me that he considered that I could be a good teacher and researcher in Metallurgy, and asked me to apply for a fellowship under the Technical Teachers' Training (TTT) program of the Ministry of Education, Govt. of India. According to this scheme, those who could qualify under the TTT program, would be allowed to enroll themselves for the Master's degree in an institution of their choice, and at the same time would be acting somewhat like a teaching assistant in US universities. On completion of the three-year program, a lecturer's job in a good academic institution was assured. Accordingly, after my training period was over, I joined as a Lecturer of Metallurgy in my alma mater, BE College. I completed my Master of Engineering and then got enrolled for my Ph.D. under the Calcutta University with Professor Seal as my Guide in both the cases. The topic of my Ph.D. dissertation was the development of Fe-Mn-Ni based maraging steels. By the time the experimental part of my research work was complete, I was selected for a Commonwealth Scholarship to pursue Ph.D. in the University of Birmingham (UK) under the guidance of Professor RE Smallman, the renowned Physical Metallurgist. Since Professor Smallman, who was also the departmental head, could not give me sufficient time, Dr. WB Hutchinson, a bright young lecturer in the department, was made my co-supervisor. Professor Smallman told me that the University received a substantial grant from the Science and Engineering Research Council (SERC) of the UK Government for procuring an AEI-EM7 High Voltage Electron Microscope (HVEM) for the department (Department of Physical Metallurgy and Science of Materials). This 1000 KV microscope had a reasonably large specimen chamber suitable for in-microscope experiments. Further, the much higher penetration of the electron beam would allow use of substantially thicker metal foils than was possible with the existing 100 KV electron microscopes. Thus, for the first time, it was possible, for example, to carry out in microscope heating experiments on heavily cold-worked and rather thick metal foils to study their recrystallization behavior. The use of thicker foils meant that the results obtained would be comparable to those from bulk samples. Previously quite a few attempts were made to study the recrystallization phenomena in-situ in conventional 100 KV electron microscopes. However, the very fact that the foils that could be used in such microscopes had to be rather thin, and therefore not many deformed cells could be enclosed within the space between the top and the bottom surfaces of the foils, those experiments were total failures. I was quite fascinated with the idea that I could possibly be the first person to carry out in microscope recrystallization experiments in a HVEM. Therefore, I volunteered to take up a project on recrystallization studies on heavily cold rolled copper and copper alloys, using an HVEM, for my Ph.D. work. The results of these studies were beyond our expectations. The work was highly acclaimed by the scientific community. The impact of this basic work can be gauged from the following sentence. "Perhaps the clearest confirmation of the fact that the nuclei come from subgrains present in the deformed matrix is Ray et. al.'s [R. K. Ray, W. B. Hutchinson and B. J. Duggan :Acta Met. 23 (1975) 831] direct observation by HVEM of nucleation in heavily rolled copper……., the first time apparently that nucleation events comparable to those occurring in the bulk have been observed in such detail."[Ref. R. D. Doherty in "Recrystallization in Metallic Materials, Ed. F. Haessner, Dr. Riederer Verlag GmbH, Stuttgart, 2nd Edition (1978) 23-61]. After spending a year and a half in Birmingham, I took leave of about six weeks to come back to BE College. I wrote down the entire thesis of my Indian Ph.D. within that period and submitted the same before returning to Birmingham. I finally came back to India after completing my British Ph.D. in April 1973 and was immediately promoted to Assistant Professorship in BE College. Within a few days I sat for the oral examination for my Indian Ph.D. and therefore I received two Ph.Ds in the same year. The next year was a very important year in my life, since in January 1974 I tied the knot with my wife, Chhabi. I have no hesitation in confessing that whatever I have achieved in life is to a very great extent due to the fantastic support and understanding I received all throughout from my dear wife.

BE College used to be a state government-run institution those days. For the number of students enrolled every year, the number of teachers was abysmally few. Because of the total apathy, insensitivity and ignorance of the state politicians and the mandarins in the Writers' Buildings, the secretariat, the

infrastructure, both for teaching and research in BE College, deteriorated very fast and most of it became rather obsolete within the span of a few years. Thus, BE College, which once enjoyed the reputation of a premier academic institution in the country, soon became like a local college, both with respect to infrastructure and talent. As I found out that it was impossible to carry out any meaningful research in BE College, I started nurturing the idea of leaving BE College and join one of the newly created Indian Institutes of Technology in the near future. A few visits to IIT Kharagpur and IIT Kanpur convinced me that for doing good teaching and research, IITs would be the ideal places for me.

I was so determined to leave BE College that against all advice from my parents and well-wishers I joined IIT Kanpur, not with a promotion but at the same level as an Assistant Professor, in 1977. I could immediately see the gulf of difference between an IIT and a state government run engineering college, both teaching and research-wise. That difference only increased over the years and I could see the highly deplorable condition BE College fell into. The more I thought about it more I got convinced that in India if we want to produce first grade engineers, all engineering and technical institutions should be brought under the care of the central government. That will ensure that both teachers and students will come from different states of the country. This cosmopolitan fabric will not allow the local political goons to hijack the control of such important institutions, and at the same time will allow their healthy growth.

IIT Kanpur, during those days used to be a fantastic institution. I was highly impressed with the tremendous freedom and flexibility offered by the institute, in terms of academic curricula and courses, and research and teaching programs, which was quite unthinkable even in other IITs. Another very important aspect was the complete absence of hierarchy within the departments and in the institute. These were the attributes which made IIT Kanpur a completely different kind of academic institution in the country. I started getting, at a slow but steady rate, a number of brilliant M.Tech. and Ph.D. students, some of whom later distinguished themselves in their chosen careers. I am glad to mention here that a few of my former Ph.Ds turned out to be excellent teachers and researchers in some of the prestigious institutions in the country and abroad. While doing Ph.D. in Birmingham I learnt that crystallographic texture of materials, like their microstructure, affect the properties significantly. In fact, during those days, techniques of texture measurement were being developed and perfected in a select number of academic institutions and research organizations in several countries of Europe, a few organizations in the USA and in Japan. There was not a single institution in India where any serious research activity took place in the areas of crystallographic textures of materials. With my limited knowledge in textures I wanted to make a beginning in research in this area at IIT Kanpur. I started working with a primitive texture goniometer existing in the Advanced Centre for Materials Science in the institute. The operation of this equipment was totally manual and collection of texture data from one sample used to take almost a full day. I was still very happy that at least I could do some work in the textures area, using this equipment. I was awarded a Humboldt research fellowship in 1981 to work with Professor K. Luecke, Director of the Institute for Physical Metallurgy and Metal Physics in the Technical University of Aachen, in Germany. Professor Luecke was one of the two pillars of modern texture research, the other being Professor HJ Bunge of Clausthal University in Germany. My two years' stay in Aachen has been extremely useful to me in learning the techniques and applications of crystallographic texture. After coming back to IIT Kanpur I built up a small facility for undertaking texture-related research (but still without a modern texture equipment). Using my wide network in Germany as well as in DMRL, Hyderabad I could manage to carry out critical texture measurements for my students' theses. Thus, possibly for the first time, meaningful texture research started in India in a moderate way. In 1997 I wanted to hold the first national seminar on textures in materials, to take stock of the pool of scientists and engineers in the country with active interest to work in this area. My idea did not get any response either at the departmental or at the institute level in IIT Kanpur, for some inexplicable reasons. Since my request to hold this meeting in IIT Kanpur was summarily turned down, I started looking for other

alternatives. Fortunately for me, Professor Dipankar Banerjee, the then Director of DMRL Hyderabad, agreed to provide me all help for holding the National Seminar on the Application of Textures in Materials Research (NASAT) there. The seminar was a great success and was attended by about twelve overseas experts on textures, including Professor HJ Bunge, fondly known as the father of modern texture research. In addition, about thirty-five delegates from within India also participated. The proceedings of this seminar were published as a volume entitled Textures in Materials Research. This event singularly helped to put India firmly on the Texture map of the world. For pioneering texture research in India, I was made a member of the International Committee on Textures of Materials in 1999, the first and the only member from India. It was after the successful meet during NASAT-97, I started thinking about establishing a National Centre for texture studies in India. In fact, a number of prominent metallurgists in the country assured me of all help in this effort. However, it soon became apparent to me that, both in the departmental and in the institute level at IIT Kanpur, this proposition would be rather unwelcome. I therefore stopped nurturing this idea. I felt extremely happy when, after a few years, a national facility was indeed set up in the Materials Engineering Department of IIT Bombay with a grant from the DST, under young and energetic Professor Indradev Samajdar. By the time I retired from IIT Kanpur in 2005, texture research in India picked up in a big way and a large number of scientists and researchers, in academic institutions, national research laboratories and in the R&D laboratories in a number of industries, were engaging themselves routinely in texture studies on various materials. Thus, what I started single handedly about forty years ago, has now developed to such an extent that India is considered as one of the few countries in the world where high quality and meaningful research on crystallographic texture is being carried out on a regular basis. I must admit that this is the biggest source happiness and pride in my professional life. During the 15th International conference on Textures of Materials, held in 2008, I voluntarily relinquished my membership from the International committee, in favor of my younger professional colleague, Professor Samajdar, who was later inducted into the committee. In the same meeting I could convince the remaining members to choose Bombay as the venue of the next (16^{th}) International texture conference in 2011, the first time this conference was held in India.

Although when I had joined IIT Kanpur, it was a fantastic institution of learning, over the years I noticed a steady and continuous decline in the academic culture of the institute. In the IIT system, a faculty member does not have to take many classes, as in case of other engineering colleges and universities. The faculty members are encouraged to put in sufficient time and effort in doing high quality research work, for which they have ample time. I must confess that going from a small state engineering college to IIT Kanpur, I had some kind of inferiority complex to begin with. I thought I was rather small in comparison to many of the faculty members there. However, I soon realized that excepting about some 40% faculty members, most of the others were really not that great. There were quite a few who neither taught well, nor did any worthwhile research. This kind of a situation is very fertile to breed dirty politics. As an elected member of the Board of Governors in IIT Kanpur for two years, I had ample opportunity of observing the working of the institute from close quarters. I was appalled at the extent of politics in almost all spheres, and this peaked during selection and promotion of faculty members. No wonder that the IITs do not figure within the top 100 academic institutions in the world. It is time to strictly implement a system so that only the most qualified and competent academicians are selected and promoted. There should be another system to monitor the academic and administrative output of every faculty member on at least a yearly basis. To start with, for the purpose of promotion to higher positions, the method followed in the Indian Institute of Science, Bangalore may be adopted. Again, the total contribution of a faculty member should be evaluated, on the basis of his/her teaching, research and administrative performances. Once it is ensured that only the good and deserving people can go to the top, all other problems of the institute will automatically vanish.

For the last ten years or so, all the academic institutions in the country, including the IITs, have been facing the problem of poor attendance in classes by the students. This is a terrible wastage of money, time and manpower for the nation. During the last few years of my stay in IIT Kanpur, I extensively interacted with many students. As per their version, the reasons for their poor attendance are: (1) poor teaching quality, (2) lack of motivation, (3) lure of high salary in the IT sector, for which just the engineering degree is needed, not any education, (4) easy availability of lecture materials through the internet and (5) urge for more freedom to choose the time and pace for learning a subject. Although this appears to be the biggest challenge for engineering education in our country, this can be turned into a very big opportunity. As we are all aware, the engineering education imparted in our country is highly deficient in the sense that here it is mostly bookish knowledge, as a result of which a graduate engineer hardly knows anything about practical engineering aspects. This has time and again been pointed out by the leaders of the various industries also. I would suggest a radical departure from the conventional engineering education as is practiced in India. On every subject high-quality e-learning courses can be produced, through the auspices of NPTEL and/or some other agencies and the students may be given easy access to those courses. The students need not come to formal classrooms for learning, rather they can learn at their own time and pace. There should be a few formal contact hours with the teachers, when a student can clear up the deficiencies he/she may have by discussion with the teacher concerned. This will release a large amount of time for the teachers who can concentrate on research. Everyday a few hours should be set aside when a student will be taught the practical aspects of the relevant engineering course he/she is registered in, especially in modern manufacturing practices and design along with hands-on experience with sophisticated instruments. The marks allotted to these practical courses must have a substantial part based on attendance. This way we should be able to not only solve the problem of students' non-attendance in classes, but will also motivate and equip them better for future employment.

When I was near retirement from IIT Kanpur, I got an invitation to serve as a Visiting Scientist in the R&D Division of Tata Steel, Jamshedpur. My job description was to offer critical technical/scientific input on R&D research programs during the formulation and execution stages, to actively participate in specific projects undertaken by R&D, to hold special lectures on selected topics from time to time, to review the progress of research projects and to guide researchers so that they could write excellent research reports and technical/scientific papers and patents. In addition to these I was also requested to produce an e-learning course on X-ray Diffraction, with technical support from Tata Interactive Systems in Kolkata. After retirement from IIT Kanpur I started my work in Tata Steel full-heartedly. The Chief of R&D and Scientific Services of Tata Steel during that period was Dr. Debashish Bhattacharjee, an excellent technocrat and scientist with impeccable credentials. It was a wonderful time and I got into my task with the same vigor and purposefulness which I had in IIT Kanpur. Things went smoothly for the first few years when I was instrumental in getting a reasonably large number of papers published from the work done by researchers in R&D. I used to spend a lot of time discussing research problems with researchers and helped them in learning various techniques needed in research activities. In fact, I thoroughly enjoyed my job in Tata Steel. Then came a sudden change. The Tata Group bought Corus (a steel company with assets in both UK and the Netherlands) and Dr. Bhattacharjee left for Europe as Group Director of R&D Tata Steel with control over both Tata Steel India and Europe. A steady deterioration in R&D in the Jamshedpur plant started after the departure of Dr. Bhattacharjee, and it continued to become worse and worse. I finally left Tata Steel R&D in 2014. My ten years of service in Tata Steel R&D gave me a rare insight into the working of the top private sector steel plant in India. As a Visiting Scientist I used to send, after every two years, a critical report to the Managing Director, outlining the steps needed to improve things within R&D. I do not know what happened to those reports, however, I started having a feeling that the top management possibly was not that concerned with the health of R&D. They possibly were very happy that they, after all, had an R&D to give them some tax benefit from the Government. Tata Steel R&D those days had an excellent crop of very high-grade

researchers, coming from the IITs and the Indian Institute of Science, Bangalore. Compared to many of them, the group heads and the Chief of R&D appeared to be rather ordinary. The result was simple. Due to total apathy of the top brass in R&D these bright young boys and girls started leaving the R&D in large numbers. The vacant positions would be filled by new recruits, fresh from colleges. I brought these facts in my reports to successive MDs since I felt that the persons who left were the "value-added products", well versed in research and the new recruits were like "raw materials" and therefore no match for those who left. However, to my surprise I found that the Tata Steel bosses firmly believed that nobody was indispensable for the company and therefore no attempt was made to retain good researchers in R&D. This came as a big surprise to me. I was also shocked that Tata Steel R&D, which is the first industrial R&D in the country, and was more than 75 years old, lacked some of the basic equipments for research. Even now they do not have a vacuum induction furnace for melting experimental steels and a laboratory-scale rolling mill. It is high time they go for a total revamping of their facilities, otherwise nothing tangible will come out of that laboratory. As a result of all these, Tata Steel R&D is nowhere in comparison to the R&D departments of the major steel plants in the world, like Arcelor-Mittal, Nippon Steel and the steel companies in South Korea and China.

After my stint with Tata Steel finished in 2014, I joined as a Visiting Professor in my alma mater, BE College which has now become Indian Institute of Engineering Science and Technology (IIEST), administered by the central government. Life has turned a full circle for me. I started my career from BE College and now, at the fag end of my life, I am back again in the same institution.

When I look back, I think I am one among a handful of engineers (metallurgists) who worked both in academics and in industry. Surprisingly, I found plenty of similarities in both these types of entities. For example, politics reigns supreme in both, it is of course far dirtier in industry than in academics. A genuinely good and competent person faces lot of opposition from the mediocre (their number is obviously very large) who join in a formidable group and push the good one against the wall. The person concerned either leaves the organization or, if he/she cannot leave due to personal or family reasons, gradually gives up and becomes a member of the mediocre group. As a country we really cannot afford this anymore. The situation can change only when very bright and visionary persons are brought at the helm of affaires everywhere. It is indeed a matter of shame that bright young people who join an organization in India, find it extremely difficult to work and give their best. The same persons, when they go abroad, do wonderful work. The reason is very simple. In our country very small people unfortunately occupy very big chairs. This has to stop forthwith. If the top person is bright and first-grade, he/she will recruit only the first-rate persons. On the other hand, if the top person is second or third grade, he/she will keep on recruiting only the third or fourth grade people.

Our government over the last quite a few years has been emphasizing the need for quality research work in the country, in academic institutions, research laboratories and in the R&D laboratories in the various industries. From my limited experience I have seen how the top brass in an industry gives only lip service, so to say, for advancement in research. They are just bothered about how to maximize the profit of the company during the period of their tenure, and therefore do not want to take any risk. The other most important point is that the top persons in most of the Indian industries are just graduates in engineering with a diploma or degree in business management. Because they have not done any research work during their life-time, they have absolutely no idea about what research is and what is essentially required for undertaking worthwhile research activity. Of course, there are very few exceptions also. But, by and large, this is the existing scenario. That is the reason why no landmark research has ever been carried out in the area of either product or process development, for example, in our steel industry laboratories. The remedy is to appoint very good and competent engineers, with substantial research experience, preferably a Ph.D. at the level of Managing Directors or Presidents of the companies. Our industry can only progress

and become at par with the industries in the West, in China, Korea or Japan only by developing competitive technologies through sustained research. Otherwise, Indian industry will never be a leader in the world and will remain an inefficient follower all along. It is my fervent appeal to the Indian National Academy of Engineering (INAE) that they seriously start considering the measures necessary to improve the quality of engineering education in India, and at the same time start advising the industries on how to improve the quality of research, so that the country can forge ahead with high quality engineering manpower and knowledge (research) based modern engineering enterprises. INAE has to interact with the relevant Government departments, academic and research institutions and industries and roll out, after due deliberations, the way forward.

After spending nearly fifty years of my life in teaching and research, when I ask myself "are you happy?" the answer comes in a flash "yes, of course, because this profession is so fulfilling". I am a totally satisfied and utterly happy person, with no regrets whatsoever. Yes, it is true that I did not receive many accolades and awards, like many others, but that has nothing to do with my inner self, which is totally at peace and happiness. If I am asked to advise a budding engineer on which profession to choose as a career, I would definitely tell him/her always to consider teaching/research as a worthwhile option, although many will say "R.K. Ray is totally biased"!

Setting up of Homi Bhabha National Institute

R B Grover[1]

The Beginning

The nuclear power programme in India started with the setting up of boiling water reactors at Tarapur, near Mumbai, by a US company on turnkey basis. In parallel, decision to construct pressurized heavy water reactors, in collaboration with Canada, was taken. International cooperation ended abruptly after peaceful nuclear explosion conducted by India in May 1974. Since then and until recently India had been following an autarchic path for the development of nuclear power. Considering its nuclear fuel resource position and large energy needs, India has decided to pursue a closed fuel cycle, which can enable exploiting full energy potential of uranium and makes it possible to exploit plentiful thorium for energy generation. While the situation about international cooperation changed in favour of India in the year 2008 [1, 2], not many countries are pursuing a closed fuel cycle approach and India has to pursue this path based on innovations within India.

Innovation needs inputs at all levels: research, technology development and technology deployment. The Department of Atomic Energy (DAE) has set up a network of institutions to implement all levels and is well poised to increase installed nuclear capacity based on existing as well as innovative technologies. All institutions in the DAE pursuing research and development need to work synergistically to accelerate the pace of implementing innovations and this called for devising an enabling framework.

DAE institutions have been running academic programmes, particularly doctoral programmes, since their inception. For the award of academic degrees, they were affiliated to various universities in the country, an arrangement not considered satisfactory. Bureaucratic approach common in the university system frustrates any attempt to improve quality or introduce innovations. Doctoral research has twin objectives: training a student in doing research, and doing research. By choosing topics for doctoral research related to the mission of the Department, a lot can be achieved as a thesis documents - four man-years of research by a bright young graduate student. This motivated the Department to set up a university that can help in the growth of doctoral research, provide for joint guidance of students from within and across DAE institutions, and improve training of the student and the quality of doctoral research. Such an idea was first mooted

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during a seminar held in 1995[2], but it did not gain traction. Discussion on this idea resurfaced in the year 2002 and was endorsed by various bodies within the Department including DAE Science Research Council[3], an advisory body consisting of eminent scientists set up in 2001 to advise the DAE in identifying thrust areas to be taken up for research, upgrade the level of ongoing research and other similar aspects. It was also endorsed by the Chairman's Advisory Committee[4].

For the course based programmes, as run in the BARC Training Schools, it was not possible to award any degree and the programme was being run as a non-formal programme[5]. The programme at the Training School has evolved as equivalent to the course work for a M.Tech., and the Training School has been functioning like a Graduate School of any university. Converting the non-formal academic programme at the Training School into a formal programme called for setting up or affiliation with a university. In addition, Tata Memorial Centre (TMC) was running post-graduate programmes in medicine, but the scope (spread in terms of specialization, as well as number of students admitted) of the programme was much narrower than the potential of TMC.

With this background, in April 2003 Dr. Anil Kakodkar, the then Secretary, DAE constituted a steering committee to advise the Department on all aspects of setting up of Homi Bhabha National Institute (HBNI) as a deemed to be university. This enabled the Department to get advice from eminent educationists like Prof P. Rama Rao and Prof. S. P. Sukhatme. The author was the member-secretary of the steering committee.

Accreditation

The proposal from the DAE

Tata Institute of Fundamental Research (TIFR) could get the status of a deemed to be university in the year 2002 based on independent efforts. It was, therefore, decided to include under HBNI only the following ten institutions.

Research and Development Centres

a. Bhabha Atomic Research Centre (BARC), Mumbai;
b. Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam;
c. Raja Ramanna Centre for Advanced Technology (RRCAT), Indore;
d. Variable Energy Cyclotron Centre (VECC), Kolkata;

Grant-in Aid Institutions

e. Saha Institute of Nuclear Physics (SINP), Kolkata;
f. Institute for Plasma Research (IPR), Gandhinagar;

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[2] A seminar to discuss Vision 2020 of the DAE was organised during July 17 – 21, 1995 in BARC. During the session, titled DAE – Universities Interaction, a proposal to set up a deemed University with constituent units and grant-in-aid centres of the DAE forming campuses of the university.

[3]. The idea of setting up a university level institute was strongly supported by the DAE Science Research Council in a meeting held on January 26, 2003.

[4] Chairman's Advisory Committee is chaired by the Secretary, DAE and senior officers of DAE are members. It endorsed the setting up HBNI in a meeting held on February 15, 2003. In its meeting held on April 9, 2004, it emphasized that doctoral research should be on topics of interest to the mandate of the Department.

[5] Learning can be formal, non-formal or informal. Learning provided by an accredited educational institution and leading to certification is formal learning. Formal learning is intentional from the perspective of a learner and is structured. Learning from daily life activities related to work, family or leisure of an individual is informal learning. Non-formal learning is not provided by an accredited institution and doesn't lead to certification. It is, however, structured and from learner's perspective, it is also intentional.

g. Institute of Physics (IoP), Bhubaneswar;
h. Harish-Chandra Research Institute (HRI), Allahabad;
i. Tata Memorial Centre (TMC), Mumbai; and
j. Institute of Mathematical Science (IMSc.), Chennai

All the above institutions formally concurred with the idea of setting up of HBNI. Pending details, 'in principle' approval of the Atomic Energy Commission was taken in July 2003. After working out all details in accordance with guidelines for deemed to be universities issued by the University Grants Commission (UGC) in the year 2000, the proposal was submitted by the Secretary, DAE to the Ministry of Human Resource Development (MHRD) and the UGC in January 2004.
A Council of Management was constituted vide an office order dated November 18, 2004 and HBNI was registered as a Society. The Office Order designated the author as the Director and Dr. R.R. Puri was designated as the Dean.

The review by the UGC for accreditation
The UGC appointed a committee chaired by Prof S. K. Joshi for screening all proposals received by them. Among others, the Committee included Prof B. S. Sonde, Prof P. N. Tandon and Prof M. Anandakrishnan as members. Based on a presentation by HBNI on November 22, 2004, the committee recommended our case for a visit by an expert committee subject to our fulfilling certain conditions. Conditions not being onerous, we decided to take further steps including having first meeting of the Academic Council on January 7, 2005. Boards of Studies were constituted, academic programmes to be launched were finalized, and the presentation to be made to the Expert Committee to be set up by the UGC was discussed.

The UGC constituted an Expert Committee under the chairmanship of Prof. S.K. Joshi with Prof. G.K. Mehta, Dr. Harinarayana Kota, Dr. N. Rudraiah, Prof. G. Sundarajan as members and Dr. (Mrs.) Pankaj Mittal as Member-Secretary. The committee visited HBNI during March 28-29, 2005 and recommended grant of deemed to be university status to HBNI with ten constituent units. The recommendations of the Expert Committee were accepted by the UGC in its meeting held on April 1, 2005 and were later approved by the MHRD. A notification declaring HBNI as a deemed to be university along with ten constituent units was issued by the MHRD on June 3, 2005.

Early years
All ongoing academic programmes, which were accredited with various universities were approved and it was decided to accredit non-formal programme at BARC Training Schools as course work for an M.Tech. from HBNI. To complete an M.Tech., one-year project work was added to the course work as per the norms of All India Council of Technical Education. It was also decided that there should be student-specific doctoral committees for every doctoral student to maintain academic standards. Appropriate course work and an oral general comprehensive examination were also made compulsory for doctoral students. Ordinances for all academic programmes were written after due deliberations.

Faculty
The concept of HBNI mandated that the scientific staff working in various units would work as faculty. A framework for recognizing scientific staff as faculty was evolved. It provided for recognizing only those who have a Ph.D. and enough good publications. In case of institutions

like SINP, IoP, HRI and IMSc, individuals are recruited and progress through career as faculty and therefore, all were recognized as faculty. In case of medical doctors, it meant following the norms of Medical Council of India and this was the case regarding TMC. In the case of R&D centres, individuals are recruited as scientific officers after a rigorous selection process including an all India screening test and an interview, but only some go on to pursue doctoral research. As a result, only a small percentage (less than 10% of the total[6]) qualified as faculty. In case of IPR, the situation is mixed with some recruited as faculty and some as scientific officers. It was challenging to designate only a small percentage as faculty and several senior colleagues expressed gentle resentment. After all they had also joined DAE institutions after a rigorous selection process and many possessed in-depth knowledge in their subject of specialization. To gain from in-depth knowledge of such individuals, concept of 'Technology Adviser' for doctoral and masters' students was introduced. Select individuals were designated as Technology Advisers and this became a win-win situation; students benefited from their advice and such advisers became involved in the process of building HBNI.

Setting up a Central office

A Central Office of HBNI was established and all institutions were requested to set up a university cell. Getting administrative manpower to run the Central Office was a challenge. With no comparable model in the country, all had difficulty in visualizing manpower requirements. We started with a small complement of staff and added staff as clarity emerged. Still staff is less than optimum and request by HBNI for creation of additional posts is being processed.

External reviews after accreditation

Review by the UGC

The UGC requested for a review of HBNI in October 2009 by a seven-member expert committee under the chairmanship of Prof J. V. Narlikar. The Committee met for the first time in Mumbai on January 12, 2010 and after visiting some of the units met again during April 1-2, 2010 when representatives of the constituent units were present.

Acknowledging the special character of HBNI, the Committee observed, "HBNI is a unique research-oriented university and therefore, it should not be viewed in the same way as a standard teaching cum research university." Commenting on research facilities, the Committee said that HBNI has excellent experimental facilities in areas like materials, reactor design and operations, and lasers, which are unique in the country. With regard to theoretical research in areas like plasma, reactor, accelerator and high energy physics, and pure mathematics, the Committee observed that "it is of very high standard when judged against the national background." Continuing, the Committee noted, "The research work related to technological aspects is of very high quality."
The Committee was impressed by the expeditious evaluation of theses and the efficiency of general administration. The committee observed that "HBNI is well expected to fulfill its vision of carrying cutting edge science and technology to large number of students."

Review by the MHRD

By the middle of 2009, 128 institutions had been declared as deemed to be universities and MHRD issued a notification constituting a committee to review the functioning of all deemed to be

[6] Total includes those who join as scientific assistant and are promoted based on years of service or on the basis of acquiring higher qualification.

universities with the objective of examining academic standards. The Review Committee had four members namely Prof P N Tandon, Prof Goverdhan Mehta, Prof Anandakrishnan and Prof Mrinal Miri and it based its evaluation on a set of nine parameters. The first parameter was "Considerations of the idea of a university" and this is a parameter having multiple viewpoints. It has been extensively debated and is discussed in detail in a later section. Inclusion of this parameter was a challenge to the approach followed by the expert committees who had earlier recommended to the UGC bestowing the status of deemed to be universities on various institutions. The second parameter was "Whether all their present academic activities/ programmes could have been carried out without being a deemed university; how the status of deemed university became a stimulus for better performance." This has two parts and the first part was also a challenge to the work done by the previous expert committees set up by the UGC. The remaining parameters were all non-controversial.

We submitted a report and interacted with the Review Committee on September 19, 2009. The Review Committee graded universities in three categories namely A, B and C [3]. HBNI was placed in the category 'B', which meant that some corrective measures are needed. For the first parameter, namely "Considerations of the idea of a university", HBNI was assigned zero marks. For most other parameters, HBNI was given 3 out of 5. This was despite excellent faculty, voluminous quality research output and a well-established doctoral programme. The divergence of opinion between the Committee established by the UGC and the Review Committee by the MHRD was disconcerting. The author informally spoke to one member of the Review Committee with the objective of knowing the philosophic basis of evaluation. This talk was rewarding as it helped to understand the concerns of the Review Committee. Our response was to explain our philosophy and wherever needed, make improvements. This was in contrast to the approach followed by some others who legally challenged the finding of the Review Committee.

In February 2011, the MHRD constituted a Task Force to reexamine deemed to be universities which were placed in category 'B'. The members of the Task Force were the same as of the Review Committee. We submitted a report to the Task Force in March 2012 and a revised report incorporating suggested revisions in August 2012. We had a personal interaction with the Task Force on August 21, 2012 and finally in October 2012, HBNI was placed in category 'A'. This meant that HBNI satisfies 'most of the criteria for the deemed university status'.

Review by the National Assessment and Accreditation Council (NAAC)

The process of accreditation by NAAC involves submitting a letter of intent, preparing a self-study report in a prescribed format, visit by a peer team for personal interaction and accreditation by the NAAC after the report of the peer team is accepted by the NAAC Council. The preparation of the self-study report for HBNI was an enriching experience and helped our understanding of running a university. While compiling details of faculty, we were happy to note that about one hundred members of faculty are fellows of various prestigious academies.

NAAC accredited HBNI with a CGPA of 3.53 on a four-point scale valid until 10 May 2020.

Ranking under National Institutional Ranking Framework

The National Institutional Ranking Framework (NIRF) was approved by the MHRD and launched on September 29, 2015. This framework outlines a methodology, based on a set of parameters, to

rank institutions across the country. The parameters cover "Teaching, Learning and Resources," "Research and Professional Practices," "Graduation Outcomes," "Outreach and Inclusivity," and "Perception". HBNI was ranked 17 in the India Rankings – 2016 released on April 4, 2016. Ranking could have been better, but for the fact that only those publications were considered as that of HBNI, where authors explicitly indicated their affiliation to HBNI. Many students and members of faculty, mention only the name of the Constituent Institution and such publications were not considered as that of HBNI.

Setting up National Institute of Science Education and Research and its Integration with HBNI

Based on the recommendations of the Scientific Advisory Council to the Prime Minister, in 2006 the MHRD established two institutes, both named Indian Institute of Science Education and Research (IISER), at Pune and Mohali. To add to the efforts of MHRD, the DAE set up a similar institute at Bhubaneswar and this institute was named National Institute for Science Education and Research (NISER). While announcing the setting up of NISER on August 25, 2006, the then Prime Minister announced that it should be a part of HBNI.

IoP was tasked by the DAE to execute the project of setting up NISER. All students admitted to NISER became students of IoP and hence HBNI. Eventually NISER became independent of IoP and therefore, HBNI applied to UGC in 2009 to declare NISER as a constituent of HBNI. Almost in parallel, MHRD constituted the Review Committee referred to earlier to review all deemed to be universities. The UGC could not take up our request as HBNI was placed in category 'B' by the Review Committee. We again approached the UGC after HBNI was categorized as 'A' by MHRD. The response from the UGC came in the form of several queries and stipulations. The main point was to get accreditation from NAAC prior to integration of NISER into HBNI as an independent unit.

In the meanwhile, the UGC issued regulations for deemed to be universities and HBNI had to move on two fronts: one was to amend Memorandum of Association (MOA) and Rules to comply with the UGC (Institutions deemed to be universities) Regulations, 2010 and the second was to approach NAAC. We amended the MOA and Rules, which was a laborious process as one had to negotiate bureaucratic labyrinthine. The amendments involved re-designating Director as Vice-Chancellor and designating a Chancellor. Dr. S. Banerjee, former Director, BARC and former Secretary, DAE was designated as Chancellor.

After amendments and NAAC accreditation, all documents were submitted to the UGC in July 2015 and after more hiccups, the UGC notified NISER as an off-campus centre of HBNI in February 2016, seven years after the application. HBNI now has 11 Constituent Institutions (CIs): ten constituent units and one off-campus centre.

Idea of a university

Evolution of ideas

Human civilization has come to the present stage of sophistication because of wisdom that has accumulated over centuries and has been transferred to us through successive generations. The mechanisms of intergenerational knowledge transfer include transfer within a family unit, a community, a trade guild, internship in a workplace, and institutes of education. Universities and

other institutions of higher education have been the centres for intergenerational knowledge transfer for the past several centuries and have been accomplishing their task efficiently. The idea of a university has, however, been continuously evolving. Review Team appointed by the MHRD used "Considerations of the idea of a University" as one parameter for evaluation, but presented only one viewpoint on the subject, which can be seen from the following paragraph from the report.

> *"Universities are meant to be places – which facilitate and promote critical intellectual engagement with (a) different traditions of thought and its great variety of expression, (b) modes of understanding the human condition and predicament, (c) the incredibly diverse inanimate and non-human living world.* ***Such engagement has many utilitarian and extrinsic values; but it is its intrinsic value that marks it off as a very special sort of human practice[7].*** *"*

John Henry Newman[8] had a similar viewpoint and opined that an ideal university is a community of thinkers, engaging in intellectual pursuits not for any external purpose, but as an end in itself. He envisaged an ideal university to be a place which imparts a broad, liberal education and teaches students "to think and to reason and to compare and to discriminate and to analyse" [4]. **Problem with ideas that stress only on intrinsic value is their sheer anti-utilitarianism.** These ideas are now going through evolution as can be seen by the Bologna Process[9], which as part of the European Qualification Framework has resulted in a set of three descriptors: knowledge; skills both cognitive and practical; and competence in terms of responsibility and autonomy [5]. Gazette notification on National Skill Qualification Framework issued on December 19, 2013 by the Government of India and publication of 'Skill Assessment Matrix for Vocational Advancement for Youth by MHRD are steps taken in India which recognize importance of skill development as a part of education of youth.

Tension between intrinsic value, and utilitarian and extrinsic values of intellectual engagement is central to the debate on the idea of a university. One can consider a university as **a guarantor of creative tension in which knowledge, competence and skills are held in balance[10].** The distinctive function of the university is to keep that tension: between scholarship and engagement, abstraction and application, teaching and research [6]. This tension can be seen in the contrasting viewpoints of various expert committees about HBNI.

Japanese Society for Historical Studies on Higher Education held a conference in 2005 and the main theme of the conference was "The Idea of a University in Historical Perspective." Educationists from Germany, Britain, USA and Japan participated in the conference. In the concluding remarks [7], Karoru Narisada writes that throughout the long history of the university, the process of adopting to the circumstances of each country, and fulfilling various functions has led to the co-existence of several "ideas of a university." In the same conference, Goldman argues

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[7] Emphasis by the author.

[8] John Henry Newman gave a series of lectures in 1852 in Dublin reflecting on the university's purpose that were published as a book titled 'The Idea of a University' in the same year.

[9] The Bologna Process is a series of ministerial meetings and agreements between European countries designed to ensure comparability in the standards and quality of higher education qualifications.

[10] Anne Corbett [6], has used knowledge, intellect and skills in place of knowledge, competence and skills.

that "(the Victorians) bequeathed several different ideas of a university in a single institution, and it is our task to ensure that the many are not reduced towards the one."

Importance must be given to all three that is knowledge, skills and competence, and relative importance to the three components can vary from discipline to discipline and also from student to student. Concentration on intrinsic values to the exclusion of extrinsic values is not conducive to further development of the modern society, where technology rules every aspect of life. While majority of beneficiaries of higher education will contribute to society based on the skills and competence they acquire at the university, there will always be individuals, who will develop strong intrinsic insights into knowledge and will address higher needs of the modern society.
In short, we must celebrate the co-existence of several ideas of a university.

An examination of HBNI

We may examine the concept behind HBNI in the light of several ideas of a university that have been in existence. Many workplaces including large corporations, research centres, other organizations, both national and international have come on the scene comparatively recently, and have emerged as users of knowledge and skills as well as contributors to knowledge generation and skill development. Workplaces are store-houses of knowledge that needs to be preserved and transferred. The classical approach separates workplaces, making use of knowledge and skills, from universities, which transfer knowledge and impart skills, to students. This separation is, however, not universal. In the field of medicine, schools and hospitals are integrated into a single institution or are co-located. Medical professionals teach students as well as practice their profession. The author has always wondered as to why this model has not been extended to other disciplines. Educationists always refer to unity of "education and research" and the author feels that this should be changed to "**unity of education, practice and research.**"

Nuclear science and engineering is a multi-disciplinary subject and requires a large faculty resource. Challenged by this requirement, programmes in nuclear science and engineering in institutions in India are at sub-critical level. This situation has persisted for a long time. Squeeze in public funding for higher education has led to concepts like cooperation and partnership between universities and workplaces. The model of HBNI takes this forward by integrating a 'workplace' and a 'university' in a single entity. It is a step in the process of further evolution of the 'idea of a university'. It is a very low-cost solution for providing manpower in an area crucial for national development.

Research centres of the DAE are organized in divisions to accomplish assigned tasks and a division has individuals specializing in different disciplines to work towards a mission. A university in India invariably has discipline-specific Boards of Studies. Discipline-specific boards are perhaps desirable for under-graduate studies, but their usefulness for doctoral research is questionable particularly for a multi-disciplinary field like nuclear science and engineering. To meet the requirements of regulations, discipline-specific Boards of Studies were constituted, but the existing concept of divisions at the R&D centres was not disturbed. This ensures continuation of the DAE culture of working in inter-disciplinary teams. It also fits with the viewpoint that "we should have deep and sustained communication between scientists and engineers, between theorists and practitioners" [8]. Structure of HBNI provides for such communication.

Consolidation

Integration of constituent institutions

Bringing synergy between various DAE institutions was one of the goals of setting up of HBNI. After due reflection, we came up with the idea of having one or more deans in a CI to manage academic affairs of the CI. This helped in distributing responsibility of running academic programmes and involved CIs in decision making. A Standing Committee of Deans has been constituted which meets about four times in a year. Several responsibilities are delegated to Deans and this has given them a say in governance and resulted in a feeling of ownership of the university. To manage affairs at the level of the CI, each CI has set up a university cell and one or more Standing Academic Committee(s).

The total number of doctoral students who have completed their programme will soon reach one thousand, while the annual output has already reached 200 and is set to exceed 300 by mid-2018. Number of students, who have completed an M.Tech. will also soon reach one thousand. Number of students admitted to post-graduate and super-specialty programmes in Tata Memorial Centre has increased from about ten per year prior to setting up of HBNI to 112 now. Many new academic programmes have been started. When we started, people did not know each other, but now they are working together as a team based on guidelines which have been developed collectively.

Establishing a university culture

During about eleven years of its existence, following an approach based on prudent gradualism, the HBNI has established itself as a leading research university. Prudent gradualism had to be followed on two fronts. In interaction with outside academics and officials from accrediting agencies, one had to explain the unique architecture of HBNI as a further evolution of the idea of a university. In dealing with stakeholders inside the HBNI, one had to work to superimpose a 'university culture' over the existing culture and this involved several facets: one was to explain to practicing professionals their role and responsibilities as faculty towards students; the other was to explain the difference between doctoral research that has to be completed by a student in a certain time frame versus working on large research problems which may be done by individuals or team of researchers over a longer time period. Now we have reached a situation where the university culture is understood and integrated with the existing culture.

Defining status of HBNI within DAE

While HBNI is registered as a Society as well a Trust, its status within the DAE remained undefined until 2014. This raised certain operational issues. Therefore, the matter was pursued and HBNI became a "Grant-in-Aid" institution of the DAE on February 19, 2014. The change in status was followed by steps related to manpower deployment, framing recruitment rules, financial rules etc. After accomplishing all this, tenure of the author as head of the Institute was over and Prof. P.D. Gupta, formerly Director RRCAT, took over as the Vice Chancellor with effect from September 14, 2016 after a short stint by Prof B.K. Dutta as officiating Vice Chancellor.

Epilogue

In the beginning, running of HBNI was like conducting an 'orchestra of soloists'. Normally in an orchestra, all musicians practice together and are well integrated in every way. Once in a while, a conductor is called upon to conduct an orchestra of soloists, who are accomplished musicians in their own right. This becomes very challenging for the conductor. The Standing Committee of

Deans moderated the challenge as it provided a forum for forum to all express their views and helped in building synergy. I thank all the Deans at CIs for excellent teamwork.

Thanks to all members of the team in the Central Office particularly the former and the present Deans Prof R.R. Puri and Prof B.K. Dutta. Thanks also to Associate Deans Prof Dilip Maity and Prof Adarsh Dureja, who have been efficiently running the academic unit. For evolving office procedures, Dr. Avichal Kapur and Dr. Rajan Patel made valuable contributions. Dr. Kapur, who later joined HBNI as a Registrar, was helpful in dealing with statutory agencies. Prof KS Sharma, TMC dealt with all issues related to the Medical Council of India.

Establishing HBNI was full of challenges in view of over-regulation of higher education in India. Bureaucracy, in view of regulations, is constrained to follow a compliance-driven approach rather than an intent-driven approach resulting in challenges whenever a unique situation arises. Having overcome challenges, I wish that innovation in the governance of institutes of higher education should be a continuous affair to make India a knowledge society.

In April 2003, during a dialogue related to constituting a steering committee for setting up HBNI, the then Secretary DAE advised the author to spend most of his time on human resource development. Events after this dialogue were very interesting and challenging.

DAE nominated me to be a member of a delegation leaving for Washington DC on December 17, 2003 to discuss Next Steps in Strategic Partnership (NSSP). That began my involvement with the initiative of the Government of India to open International Civil Nuclear Cooperation [1, 2]. This led to frequent travel to interact with policy wonks in several countries, and the soubriquet 'nuclear diplomat' by my friends. To work as a nuclear diplomat, it is necessary to know nuclear law. In June 2004, I received an invitation from the Director General, International Atomic Energy Agency to serve on an international expert group to examine multilateral approaches to nuclear fuel cycle. This gave me an opportunity to interact with experts in nuclear law and diplomats handling nuclear issues. The resulting exposure to nuclear law gave me the confidence to work as a nuclear diplomat.

I was heading HBNI concurrently with being the head of strategic planning in the DAE. Immediately after superannuation from the DAE in February 2013, I was appointed DAE Homi Bhabha Chair and this enabled continuation of my involvement with issues related to nuclear diplomacy including being sous-Sherpa for the Government of India for the nuclear security summit process, and representative of India in the ITER[11] Council as the Head of the Indian delegation.

Both jobs, setting up of HBNI and participation in various negotiating and outreach teams (for drafting nuclear cooperation agreement with various countries, for drafting India-Specific Safeguards Agreement and Additional Protocol thereto with the Secretariat of the International Atomic Energy Agency, outreach with countries participating in the Nuclear Suppliers Group) for opening civil nuclear cooperation were extremely demanding. Both jobs involved a giant leap of faith, both demanded quick learning, both were groundbreaking and demanded skillful negotiations. However, a "can do" outlook, and full support by the establishment and colleagues

[11] The project ITER is being built in France jointly by China, EU, India, Japan, Russia, South Korea and the USA

helped and now after having successfully accomplished my role in both, I can look back with satisfaction. Support from colleagues and establishment reminds me of a couplet by Majhrooh Sultanpuri:

"मैं अकेला ही चला था जानिब-ए-मंज़िल मगर लोग साथ आते गये और कारवां बनता गया"
"I started alone towards my destination, but colleagues kept joining and a caravan was made up."

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Civil Engineering

1. Developing Roads That Can Generate Power from Passing Traffic

Researchers are looking at advanced materials for roads and pavements that could generate electricity from passing traffic.Engineers from Lancaster University are working on smart materials such as 'piezolectric' ceramics that when embedded in road surfaces would be able to harvest and convert vehicle vibration into electrical energy. The research project, led by Professor Mohamed Saafi, will design and optimise energy recovery of around one to two Megawatts per kilometre under 'normal' traffic volumes -- which is around 2,000 to 3,000 cars an hour. This amount of energy, when stored, is the amount needed to power between 2,000 and 4,000 street lamps. As well as providing environmental benefits, this would also deliver significant costs savings for taxpayers. It currently costs around 15p a kilowatt hour to power a street lamp. Therefore 2,000 to 4,000 lights can cost operators -- which in the UK tend to be local authorities, or the Highways Agency for motorways and trunk roads -- approximately between £1,800 and £3,600 per day. Researchers say the cost of installing and operating new road energy harvesting technology would be around 20 per cent of this cost. Professor Saafi said: "This research is about helping to produce the next generation of smart road surfaces. "We will be developing new materials to take advantage of the piezoelectric effect where passing vehicles cause stress on the road surface, producing voltage. The materials will need to withstand high strengths, and provide a good balance between cost and the energy they produce. "The system we develop will then convert this mechanical energy into electric energy to power things such as street lamps, traffic lights and electric car charging points. It could also be used to provide other smart street benefits, such as real-time traffic volume monitoring."

Source https://www.sciencedaily.com/releases/2017/09/170918111830.htm

2. Teleoperating Robots with Virtual Reality: Making It Easier for Factory Workers to Telecommute

VR system from Computer Science and Artificial Intelligence Laboratory could make it easier for factory workers to telecommute.

Many manufacturing jobs require a physical presence to operate machinery. But what if such jobs could be done remotely? Recently, researchers from MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) presented a virtual-reality (VR) system that lets you teleoperate a robot using an Oculus Rift headset. The system embeds the user in a VR control room with multiple sensor displays, making it feel like they are inside the robot's head. By using gestures, users can match their movements to the robot's to complete various tasks. "A system like this could eventually help humans supervise robots from a distance," says CSAIL postdoctoral associate Jeffrey Lipton, who was lead researcher. "By teleoperating robots from home, blue-collar workers would be able to tele-commute and benefit from the IT revolution just as white-collars workers do now." The researchers even imagine that such a system could help employ increasing numbers of jobless video-gamers by "game-ifying" manufacturing positions. The team demonstrated their VC control approach with the Baxter humanoid robot from Rethink Robotics, but said that the approach can work on other robot platforms and is also compatible with the HTC Vive headset. There have traditionally been two main approaches to using VR for teleoperation. In a "direct" model, the user's vision is directly coupled to the robot's state. With these systems, a delayed signal could lead to nausea and headaches, and the user's viewpoint is limited to one perspective. In the "cyber-physical" model, the user is separate from the robot. The user interacts with a virtual copy of the robot and the environment. This requires much more data, and specialized spaces. The CSAIL team's system is halfway between these two methods. It solves the delay problem, since the user is constantly receiving visual feedback from the virtual world. It also solves the cyber-physical issue of being distinct from the robot: once a user puts on the headset and logs into the system, they will feel as if they are inside Baxter's head. The system mimics the "homunculus model of mind" -- the idea that there's a small human inside our brains controlling our actions, viewing the images we see and understanding them for us. While it's a peculiar idea for humans, for robots it fits: "inside" the robot is a human in a control room, seeing through its eyes and controlling its actions. Using Oculus' controllers, users can interact with controls that appear in the virtual space to open and close the hand grippers to pick up, move, and retrieve items. A user can plan movements based on the distance between the arm's location marker and their hand while looking at the live display of the arm. To make these movements possible, the human's space is mapped into the virtual space, and the virtual space is then mapped into the robot space to provide a sense of co-location. The system is also more flexible compared to previous systems that require many resources. Other systems might extract 2-D information from each camera, build out a full 3-D model of the environment, and then process and redisplay the data. In contrast, the CSAIL team's approach bypasses all of that by taking the 2-D images that are displayed to each eye. (The human brain does the rest by automatically inferring the 3-D information.) To test the system, the team first teleoperated Baxter to do simple tasks like picking up screws or stapling wires. They then had the test users teleoperate the robot to pick up and stack blocks. Users successfully completed the tasks at a much higher rate compared to the "direct" model. Unsurprisingly, users with gaming experience had much more ease with the system. Tested against state-of-the-art systems, CSAIL's system was better at grasping objects 95 percent of the time and 57 percent faster at doing tasks. The team also showed that the system could pilot the robot from hundreds of miles away, testing it on a hotel's wireless network in Washington, DC to control Baxter at MIT. "This contribution represents a major milestone in the effort to connect the user with the robot's space in an intuitive, natural, and effective manner." says a researcher. The team eventually wants to focus on making the system more scalable, with many users and different types of robots that can be compatible with current automation technologies.

Source https://www.sciencedaily.com/releases/2017/10/171004142706.htm