

From the Atomic Energy Training School to the Homi Bhabha National Institute

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The Training School was established to build research and development personnel for the Department of Atomic Energy (DAE) in a manner that does not drain away senior persons from the universities, but on the contrary, gives training, employment and opportunities to young graduates passing out of universities. Graduates of the Training School have made India fully competent in all aspects of nuclear science, technology and their applications, and have also contributed to several major scientific and technological efforts outside the ambit of atomic energy. Several educational programmes have been nurtured by the institutions set up by DAE and this has enabled the Department to set up the Homi Bhabha National Institute, a Deemed to be University, and further expand the educational programmes and intensify research and innovation through the medium of research students.

Keywords: Atomic energy, educational programmes, nuclear science and technology, training school.

Introduction

Homi Bhabha initiated indigenous development of atomic energy immediately after India's independence and the pace of work expanded with the setting up of the Department of Atomic Energy (DAE) in 1954. In the early years, manpower was drawn from universities in India and abroad, but considering the fast growth of the atomic energy programme, it was necessary to look at innovative ways for recruiting and training manpower. Therefore, the Atomic Energy Training School (now called the BARC Training School) was started in 1957, and every year graduates from a variety of disciplines were recruited to the Training School. The then higher education institutions in India did provide educated youth to whom advanced knowledge in the area of nuclear science and technology could be imparted to prepare them for the task.

The BARC Training School has continued without any interruption for over 60 years. India is in fact one of the few countries in the world to have had a sustained training programme for nuclear energy professionals for such a long period. Over the years, the Training School has ac-

quired legendary status and the spread of programmes run at the School have increased.

While formal records about the proposal to start the Training School could not be located, opinions expressed by many, who were then working with the Department, are available. For example, Venkataraman¹ opines

‘In a sense, this was like recruitment to the prestigious Indian Administrative Service (IAS) – except that unlike in the case of IAS, the recruitment here was via interviews by expert committees, rather than via written examinations. Bhabha also campaigned hard so that his trainees got reasonable salaries comparable to those offered in the IAS, besides similar promotion opportunities. Needless to say, all this was far from easy...’

This is indicative of the debate that must have taken place before setting up the School as it involved the addition of manpower every year based on a selection process not under the Union Public Service Commission, training them for a fixed period like all India services and giving the scientists a comparable status.

Bhabha's contemporaries also recall that his efforts to modernize the university syllabus were unsuccessful and therefore, he decided to start the Atomic Energy Training School².

Bhabha³, in his lecture on 7 January 1966 to the International Council of Scientific Unions (ICSU), spoke in detail about the Training School. To fully understand his thought process, the relevant part of the lecture is quoted in extenso.

‘Additions to our scientific and engineering staff have been at the rate of between 150 and 250 per annum. To meet this requirement, the Atomic Energy Establishment in cooperation with the Tata Institute of Fundamental Research, has run a Training School in which about 150 persons have been admitted per annum on the basis of inviting applications from young men passing out of the universities every year and selecting the best of them. They are then given a year's lecture course and training in certain general as well as specialised subjects. At the end of the year most of them are absorbed into the establishment, the grading being on the basis of tests throughout the period of their

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study and an examination at the end of the year. To give an idea of the figures, last year about 3400 applied with first and second class degrees from universities, 251 were selected on the basis of an interview, 130 actually joined the School, and 125 completed the course and were appointed at the end of the year. On admission these young men became part of small scientific groups working on specific problems, and at the end of two or three years they become very useful scientists. The best among them are likely to become future leaders. We have found this method of recruitment very satisfactory, and although it has placed a heavy load on our senior staff by making the spectrum of scientific staff much heavier at the junior levels than it should be, it has provided a powerful source of able young scientists on the basis of which the programme can be expanded continuously in the future. It will be seen that this method of building up our staff does not drain away senior persons from the universities, but on the contrary gives training, employment and opportunities to young graduates passing out of the universities.'

The Training School has become an iconic institution that has supported the programmes of DAE. Almost all the leaders of the atomic energy programme during the past two decades have been products of the Training School.

The Training School

The beginning

The flagship programme at the Training School is a one-year orientation course for engineers and scientists. The first batch started on 17 August 1957. Figure 1 is a rare photograph of the first batch of trainees. It consisted of 54 physics, 38 chemistry, 10 electrical engineering, 23 chemical engineering and 16 mechanical engineering trainees. Some of the graduates from the first batch reassembled in 2018 to celebrate their Diamond Jubilee (Figure 2). Many details included in the following section were provided by the graduates of the first batch⁴.

The orientation programme continues to function and meet the demand for trained scientists and engineers. Considering the manpower demand, the programme now runs at multiple campuses and new schemes other than the orientation programme have been added. The BARC Training Schools have gained worldwide recognition as centres for the dissemination of explicit and tacit knowledge in the nuclear domain. For engineers, the course work is equal to that required for an M.Tech. programme in Indian universities and for scientists, it gives them credits needed for the course work for a Ph.D. Every year, many defence officers are deputed to the Training School to study nuclear science and engineering. No other institution in the country runs this kind of vast programme in the nuclear domain.

Training disciplines

The qualifying disciplines for admission and the training domain have evolved to address the requirements of the programmes pursued by R&D Centres and industrial units of the Department. As mentioned earlier, the first batch had trainees in physics, chemistry, chemical engineering, electrical engineering and mechanical engineering. The metallurgy discipline was added in the second (1958–59) batch, electronics engineering in the fourth (1960–61) batch, biosciences in the 15th (1971–72) batch, instrumentation engineering in the 20th (1976–77) batch, computer science in the 35th (1991–92) batch, civil engineering in the 42nd (1998–99) batch and environmental sciences in the 43rd (1999–2000) batch. The students are trained in disciplines to which they belong, that is, physics, chemistry, chemical engineering, electrical engineering, etc., but given a general orientation towards nuclear science and engineering. In some cases, training is given in an application-specific domain like quality assurance and quality control (from 2018 to 2019) or focused on a specific technology like fast reactor technology (from 2018 to 2019).

From the first (1957–58) to the 65th (2020–21) batch, approximately 2000 trainees in science and 5000 trainees in engineering have graduated from the BARC Training School (Table 1).

Training school campuses

Trainees of the first batch underwent training programme at several scattered venues in Mumbai; also, engineering trainees received a part of the training at the Indian Institute of Science (IISc), Bengaluru. After the establishment of the BARC campus at Trombay, the Training School was temporarily located in the Modular Laboratories at Trombay. Eventually, it was housed in a permanent building at the South Site, Trombay and trainees from the 14th batch were the first to graduate from this complex (Figure 3). The building at South Site is iconic and is situated on a hillock and can be approached from two sides by a gentle climb. Surrounded by trees and lawns and endowed with unique architectural elements, it was an isolated, calm, serene and picturesque location and ideal for studies and lectures conducted here from early morning to late evening.

In 2008, the activities were shifted to the new complex at Anushaktinagar, Mumbai, and it continues to operate here (Figure 4). The new complex houses both the Training School and the Central Office of Homi Bhabha National Institute (HBNI). The complex at Anushaktinagar is even bigger and better, and the location is equally picturesque and connected by a covered walkway to the students' hostel located nearby. Lecture halls and classrooms are equipped with modern electronic information technology-based teaching gadgets, laboratories and other infrastructure. With the expansion of atomic energy programmes to

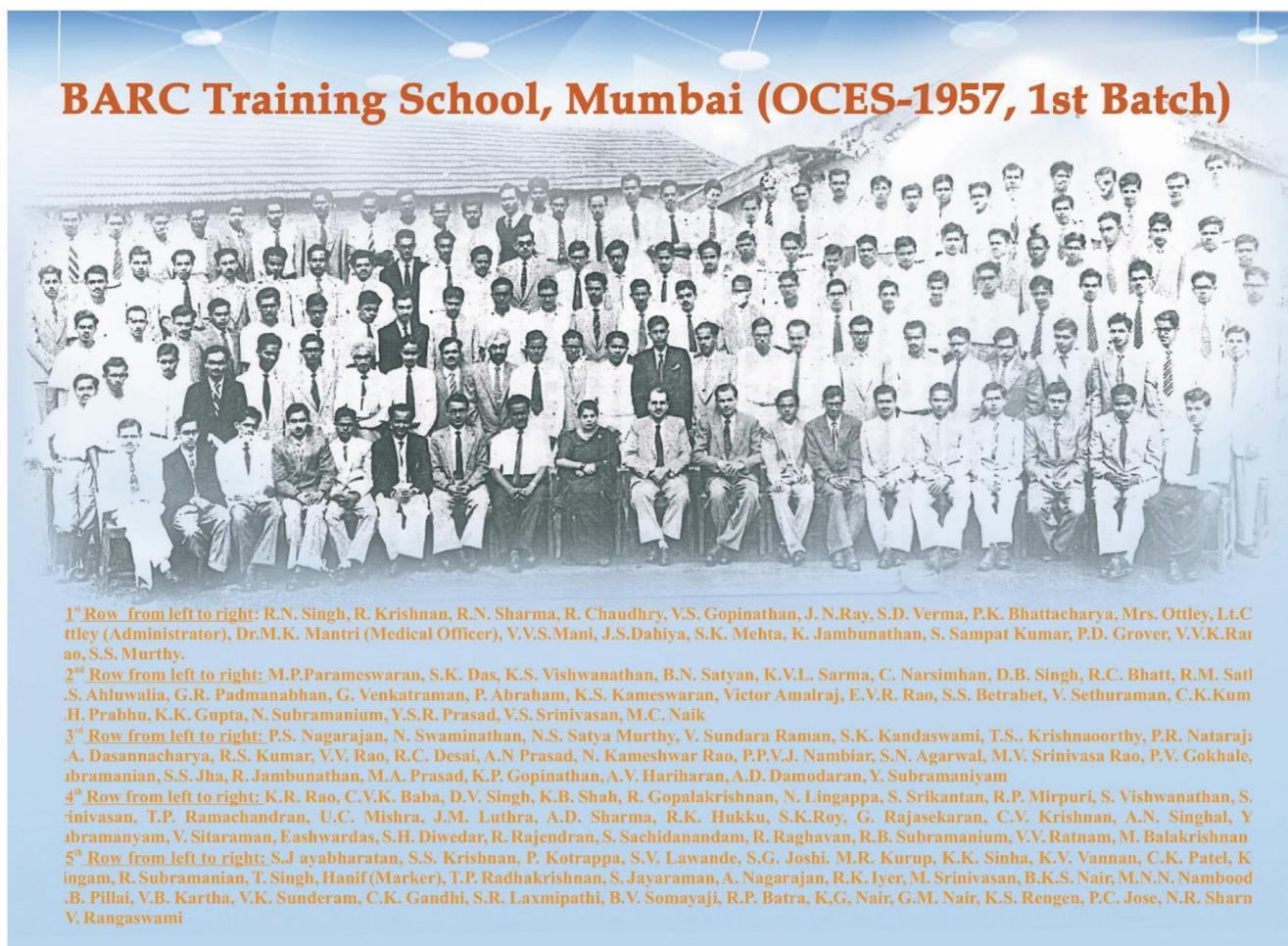


Figure 1. Group photograph of the first batch of trainees.

several locations, there has been a corresponding growth in demand for manpower and also the need for manpower in some new areas of expertise. This led to the establishment of campuses at locations other than Trombay. As a result, campuses of the BARC Training School were set up at locations appropriate for the intended specialization and presently Schools are functioning at Nuclear Fuel Complex (NFC), Hyderabad; Atomic Mineral Directorate for Exploration and Research (AMD), Hyderabad; Raja Ramanna Centre for Advanced Technology (RRCAT), Indore and Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, besides the one at BARC. Table 2 gives the fields of specialization for the different Training Schools.

The selection process

The selection is open to all Indian nationals. The scheme is popular due to a mix of factors like the possibility for academic growth, assured employment, opportunities of working in hard-core engineering and science domains, and as a result, candidates from all states of the country

apply for admission to the BARC Training Schools. The popularity of the scheme is evident from the data in Table 3 which lists the number of applications received and the number of selections in the past few years from candidates belonging to different states of India. At present, the selection for admission to the Training Schools is based on a two-stage process. In the first stage, the applicants are shortlisted based on their performance, either in an all-India level written examination conducted by BARC or in the Graduate Aptitude Test in Engineering (GATE) conducted by the National Coordination Board–GATE, Department of Higher Education, Ministry of Education (MoE), Government of India (GoI). In the second stage, the shortlisted candidates are required to appear for a personal interview which is designed to test their application of knowledge and analytical capability rather than the memorization power. The final selection is based purely on the performance in the interview. The selection process is centralized to ensure uniformity of quality across all Schools. The stringent and competitive nature of the selection process can be judged by the fact that every year while more than 1 lakh candidates apply for admission,



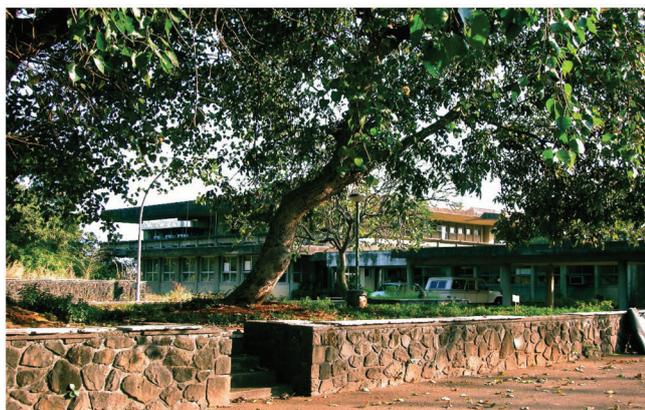
Figure 2. Some graduates from the first batch who attended the Diamond Jubilee Year Celebration in 2018, with R. Chidambaram, K. N. Vyas and A. P. Tiwari.

Table 1. Number of graduates from the first (1957–58) to the 64th (2020–21) batch of BARC Training Schools, Mumbai (since 1957), Hyderabad (since 2001 at NFC and since 2010 at AMD), Indore (since 2002) and Kalpakkam (since 2006)

Training discipline	Number graduated from BARC Training Schools					Total
	Mumbai	Hyderabad (NFC-HWB)	Hyderabad (AMD)	Indore	Kalpakkam	
Physics (nuclear physics/reactor physics/laser and accelerator physics)	1418			126	85	1629
Chemistry, including nuclear fuel cycle chemistry	138				130	268
Bioscience	232					232
Radiological safety and environmental science (for physics/chemistry/nuclear engineering)	217					217
Mechanical engineering	1700	148			153	2001
Chemical engineering	736	96			84	916
Metallurgy/materials science	375				41	416
Civil engineering	167					167
Electrical engineering	777	63		30		870
Electronics engineering	736	53		80	47	916
Computer engineering	209					209
Instrumentation engineering	316					316
Quality assurance and quality control		11				11
Fast reactor technology					10	10
Geology			121			121
Geophysics			52			52
In-plant training	760					760
OCEP/OCDF	412					412
Defence officers and other non-departmental trainees (various disciplines)	273					273

Table 2. Training schools and training specializations

Training School	Training specialization
At Bhabha Atomic Research Centre, Mumbai (since 1957) At Raja Ramanna Centre for Advanced Technology, Indore (since 2000) At Nuclear Fuel Complex, Hyderabad (since 2001)	Nuclear and related sciences and technologies Engineering physics (lasers, accelerators, cryogenics, superconductors, materials science, power electronics and microwaves) Design, engineering, construction, operation and maintenance of chemical plants (production of heavy water and fuel fabrication)
At Indira Gandhi Centre for Atomic Research, Kalpakkam (since 2006) At Atomic Minerals Directorate for Exploration and Research, Hyderabad (since 2010)	Fast-breeder reactor and recycle science and technology Geophysics and geology related to uranium and other atomic minerals

**Figure 3.** The Erstwhile Training School Complex (1970–2008), South Site, Trombay, Mumbai.**Figure 4.** The Training School and Central Office of the Homi Bhabha National Institute, Anushaktinagar, Mumbai.

only a few, approximately 1.75 per thousand candidates are successful in securing admission to one of the Training Schools (Table 4). Earlier, the screening examinations for admission to the Training Schools were conducted using the conventional pen–paper mode. This was changed in 2012–13 and now the screening examination is computer-based, the number of examination centres has been increased and simultaneously vigorous publicity is done through outreach lectures, web-based advertising and e-mails to prospective candidates. These measures have led to a significant increase in the number of applicants, making the selection more competitive (Table 4).

Faculty, syllabi and examination

The teachers in the first batch were senior scientists from BARC, Tata Institute of Fundamental Research (TIFR) and some expert faculty were invited from various other local institutions. Now, most of them are drawn from the Department, as a rich pool of well-qualified faculty satisfying academic norms is available. It is strongly believed that the scientists and engineers, actively involved in carrying out research, development and deployment activities driven by the DAE programmes, should be engaged in teaching as this is an effective means of education and knowledge dissemination. This approach combines explicit knowledge of the discipline with the tacit knowledge that comes from research and professional practice. Conveying tacit knowledge to students helps preserve the same.

The courses, syllabi and programme structure have been continuously evolving to meet the needs of the Department, and also to meet the norms and guidelines specified by the statutory bodies.

Examinations are conducted almost throughout the year. A unique feature of the examination system is the end-semester viva-voce. Rather than conducting viva-voce for a subject, it is conducted for all the subjects taught in a semester. The problem the students will be solving as employees will not belong to a discipline and by taking viva voce for all disciplines together, attempt is to make a judgement about the problem-solving ability of the students.

While in the Training School, trainees find the academic load very high and more diverse than required, but after graduation they invariably agree that the intense training programme with exposure to a wide variety of subjects had equipped them with a wholesome background for the tasks assigned to them.

BARC Training School: a unique concept

The decision-making process at large affiliating universities proceeds at a glacial speed and updating syllabi can be an arduous task. Therefore, one of the reasons for setting up the Training School was to exercise control on the syllabus by the Department itself. This limitation is not applicable to the Institutes of National Importance (INIs), all of which have come up after the setting up of the Training

Table 3. State-wise number of applications to OCES and number of selections (2013–2014 to 2020–2021)

State of permanent address	Number of applications	Number of selections
Andaman and Nicobar Islands	300	1
Andhra Pradesh	111,214	146
Arunachal Pradesh	445	1
Assam	13,125	24
Bihar	82,960	125
Chandigarh	1,720	6
Chhattisgarh	27,009	43
Dadra and Nagar Haveli	125	0
Daman and Diu	65	0
Delhi-NCR and NCT	29,532	83
Goa	579	1
Gujarat	27,681	59
Haryana	30,757	118
Himachal Pradesh	6,514	9
Jammu and Kashmir	5,144	14
Jharkhand	32,544	55
Karnataka	27,775	19
Kerala	83,191	69
Lakshadweep	36	0
Madhya Pradesh	63,907	159
Maharashtra	129,691	176
Manipur	961	1
Meghalaya	566	0
Mizoram	91	0
Nagaland	329	0
Odisha	42,744	80
Puducherry	1997	3
Punjab	12,018	35
Rajasthan	61,593	132
Sikkim	208	0
Tamil Nadu	68,661	40
Telangana	61,529	48
Tripura	1,946	4
Uttar Pradesh	183,149	433
Uttarakhand	21,730	65
West Bengal	59,740	324
Others	28	0

Table 4. Yearwise selections (2010–11 to 2021–2022) to OCES

OCES session	Selection (%)
2021–22	0.202
2020–21	0.164
2019–20	0.176
2018–19	0.150
2017–18	0.116
2016–17	0.183
2015–16	0.159
2014–15	0.263
2013–14	0.400
2012–13	0.466
2011–12	0.598
2010–11	0.454

School. However, even though the number of INIs has increased significantly in the past two decades, no INI has a large faculty that can cater to the requirements of nuclear science and engineering – a multidisciplinary area^{5,6}. The availability of faculty is an issue in other countries as well and it has been sorted out by making a consortium of univer-

sities. For example, the European Nuclear Education Network (ENEN) has been established in Europe to preserve and further develop expertise in nuclear fields through higher education and training⁷. Universities, research organizations, regulatory bodies, the nuclear industry and organizations involved in the application of nuclear science and engineering are its members. A look at the Master's programme running in the universities comprising ENEN reveals that different universities focus on a narrow range and no programme is as comprehensive as that offered by the Training School. Similarly, Canada has set up a University Network of Excellence in Nuclear Engineering (UNENE) with the participation of five universities⁸.

Other educational and training programmes in DAE

Education programmes in India have seen tremendous growth. While the focus of human resource development in DAE in the beginning was to train scientists and engineers for in-house R&D activities, in due course, with the applications of radioactivity and radiation registering a

growth, the programmes have been expanded to include the needs of such applications as well. For example, 'Diploma in Radiological Physics' was started in BARC in 1962 to train postgraduates in science in the safety aspects of radiation. This programme has been recognized by the Atomic Energy Regulatory Board (AERB) as meeting the requirements for designating the person as a Radiation Safety Officer. The students graduating from this programme are absorbed in hospitals and industrial establishments handling radiation/radioactivity. Other similar training programmes that are being successfully run include DMRIT (Diploma in Medical Radioisotope Techniques) and Postgraduate Diploma in Fusion Imaging Technology (PGDFIT). Some of these have been upgraded to degree programmes.

Another scheme, the DAE Graduate Fellowship Scheme, is designed to take advantage of the extensive M.Tech. programme being offered in the country. Students who have been selected for admission to the Training School and also have secured admission in the M.Tech. programme in select institutions, are adopted by the Department. Adoption implies offering them higher fellowship, reimbursing their tuition fee and offering them a research grant to pursue a project in the area of interest to DAE. On completion of M.Tech., they undergo a short orientation course in nuclear engineering and then join a unit of DAE.

It is worthwhile to remark that a variant of the DAE Graduate Fellowship Scheme was first implemented in collaboration with IIT Kanpur for three years. This involved selection of students jointly by the faculty from IIT and BARC. One of the present authors was involved in the selection process. An analysis of the approach towards selection indicated that while the IIT faculty were looking for students who had the capability of completing the M.Tech. programme with a certain specialization, the faculty from BARC were looking for students with a wide knowledge base and a range of skills in addition to the capability to complete M.Tech.

To take advantage of the doctoral programmes run by other eminent institutions in the country, the Department offers the K.S. Krishnan Research Associateship to students who have completed a doctoral programme in science or engineering. Such students can join a unit of DAE through this scheme. After serving as a research associate for two years and satisfactory performance, they are absorbed as permanent employees. To get oriented to nuclear science and engineering, research associates are encouraged to attend courses at the Training School.

The Homi Bhabha National Institute

The genesis

The Research and Development (R&D) Centres as well as Grant-in-Aid Institutions (GIA) of DAE have been running academic programmes for a long time. The academic programmes were either non-formal, like at the Training

School or formal like the doctoral programmes pursued in affiliation with universities who had recognized DAE scientists as faculty. Additionally, BARC had been running formal academic programmes like Diploma in Radiation Protection (DipRP), Diploma in Radiation Medicine (DRM) and Diploma in Medical Radio-Isotope Technology (DMRIT) in affiliation with Bombay University. In the early 1970s, IISc started an external registration programme wherein a student could pursue doctoral research in the home establishment under the guidance of its faculty and this programme was adopted by some of the IITs as well. Engineers from the units of DAE took advantage of the scheme and received doctoral degrees. In addition, the Tata Memorial Centre was running postgraduate medical programmes. In total, academic programmes running within the DAE establishment were quite significant, but not commensurate with the full potential for such programmes. This was realized and articulated in a seminar in 1995, where the idea that DAE should set up a university was first mooted. This seminar was organized during 17–21 July 1995 in BARC to discuss Vision-2020. However, this did not get any traction⁵.

In the following years, it was also realized that the energy requirements of the country are very large, and to exploit domestic nuclear fuel sources, solutions to the problems have to be unique to India. This would require intense academic and post-academic work, and could be intensified by setting up a university within the Department. With this in mind, the idea to set up a Deemed University was taken up in early 2003, and a group was tasked to prepare a document for submitting the proposal to the University Grants Commission (UGC), New Delhi.

The institution thus set up was named Homi Bhabha National Institute with the following as its constituent institutions (CIs).

- (i) R&D Centres
 - (a) BARC, Mumbai
 - (b) IGCAR, Kalpakkam
 - (c) RRCAT, Indore
 - (d) VECC, Kolkata.
- (ii) GIA institutions
 - (a) Saha Institute of Nuclear Physics (SINP), Kolkata
 - (b) Institute for Plasma Research (IPR), Gandhinagar
 - (c) Institute of Physics (IoP), Bhubaneswar
 - (d) Harish-Chandra Research Institute (HRI), Prayagraj
 - (e) Tata Memorial Centre (TMC), Mumbai
 - (f) Institute of Mathematical Science (IMSc), Chennai.

TIFR became a Deemed University based on its independent efforts before setting up HBNI and it continues its independent existence.

The setting up of HBNI was an arduous process. It was first established as a Society and a Trust, and HBNI was

given the status of a Deemed-to-be University in June 2005 by UGC, with the ten DAE institutions mentioned above as CIs. The National Institute of Science Education and Research (NISER), Bhubaneswar was later added to the fold of HBNI as an Off-campus Centre (OCC).

Unique challenges

Nurturing academic linkage between the 11 DAE institutions by integrating them into a university framework was not without challenges. The first and foremost was devising an organizational structure that recognizes the individual eminence of these institutions and the diversity of their programme missions. Except for NISER, all the GIAs had been established much before HBNI, and two (SINP and TMC) were established even before DAE. This was addressed by appointing Deans in each of the CIs and delegating substantial powers to them. A Standing Committee of Deans was constituted, which meets frequently and takes all decisions concerning academic governance. The resulting decentralized model of governance of HBNI, and participatory management approach facilitated integration and also preserved the administrative identity and academic independence of the individual institutions.

While in the case of GIAs, the transition mainly meant adherence to a new system of governance with several benefits that could accrue through synergy, in the case of DAE R&D Centres, entry into a university system as a CI meant different challenges. Faculty of HBNI, being employees of DAE units, are tasked with the development of power and non-power applications of nuclear science and technology. They have to balance their roles as scientists with mission-related responsibilities, and at the same time play an effective role as a mentor and guide for research students. In such an atmosphere, the students may be viewed sometimes as low-cost, but valuable manpower and sometimes also as a distraction. This divide was evident within DAE during the debate for setting up HBNI. While some in the top decision-making bodies viewed students as 'distraction' and the university function 'a strain', the majority favoured it. The experience since setting up HBNI has demonstrated that students are not a distraction, but a source of innovation, which is a necessary element for the development of technologies⁵.

A sizeable fraction of students in the DAE R&D units are young employees; they need to carry out developmental work assigned to them to be assured of good career growth and at the same time, complete their academic programmes without undue delay. However, experience reveals that developmental work is always facilitated by good academic inputs.

HBNI today

The Institute now has 44 academic programmes leading to degrees and diplomas in a variety of science and engineer-

ing disciplines, including mathematics. The setting up of HBNI has helped start new, unique academic programmes of high employment potential, such as Master's programme in medical and radiological physics, hospital radiopharmacy, occupational therapy in oncology, and nuclear medicine and molecular imaging. In the 16 years since its inception till 31 March 2022, HBNI has awarded 2058 Ph.D. degrees out of which only 580 degrees have been awarded to employees. The Institute now awards around 250 Ph.Ds in a year. Since its inception, it has also awarded 1442 M.Tech. degrees, which is a direct measure of the academic strength added to DAE, since all the M.Tech. graduates (barring some from defence organizations) are now employees of DAE.

At the time HBNI was established, the student profile was such that over 75% of them were aspiring employees of the Department. Over the 16 years, this situation has changed drastically, and currently, nearly 70% of the students of HBNI are not employees of DAE. (Of 1978 students pursuing doctoral programmes in HBNI as of date, only 606 are employees). The academic programmes of HBNI are contributing significantly to the national pool of scientific talent. Through the post-graduate and doctoral programmes in medical and health sciences, HBNI is making available a large number of specialists in oncology. It also contributes significantly to skill development in the domains of nursing, radiology, etc.

Through its alumni, the Institute is making a valuable contribution to the scientific manpower development in the country. A large number of HBNI alumni occupy positions for implementing hi-tech projects within DAE and in some cases outside, and research and faculty positions in various leading institutions and universities. Thus, far from depleting the university system, the concept of HBNI has indeed enriched the academic system in the country.

HBNI and National Education Policy-2020: cluster universities

The National Education Policy-2020 emphasizes directing research to solve national problems by setting up public universities for holistic and multidisciplinary education, called MERUs (Multidisciplinary Education and Research Universities). To establish MERUs, it provides the option of clustering Higher Education Institutions (HEIs). HBNI is indeed a cluster of 11 eminent institutions under DAE, with an emphasis on multidisciplinary research for addressing the national needs.

HBNI is not the first or only example of a university formed by clustering academic and research institutions. The earliest example of such clustering of the university system with a research laboratory is from USA, where the Jet Propulsion Laboratory (JPL) funded by NASA (since 1958) is operated by the California Institute of Technology (Caltech), and the two are co-located. The arrangement of

joint appointments between Caltech and JPL has benefited both institutions.

Sokendai (a graduate university for advanced studies) was established in Japan in 1988, which runs only doctoral programmes and creates active collaboration between several research institutions and museums.

France established the Paris–Saclay University in 2019, which shares resources of 275 laboratories, including facilities of CEA, INSERM and SOLEIL⁶.

Contribution to industry

It is common today to emphasize that universities must engage with the industry and contribute to industrial development. HBNI is in an advantageous position as industrial establishments exist within the DAE system itself (Nuclear Fuel Complex, Heavy Water Board, Nuclear Power Corporation of India Limited, Bharatiya Nabhikiya Vidyut Nigam Limited, Electronics Corporation of India Limited, Uranium Corporation of India Limited, Indian Rare Earths Limited, etc.). All these industrial establishments were started by DAE to deploy the products and processes developed by its R&D centres. Through a choice of research problems highly relevant to these organizations, the students have an opportunity to contribute to the growth of the nuclear industry.

Despite the CIs of HBNI pursuing research in areas with a focus on nuclear science and engineering, several spin-offs have found applications in diverse domains. In this Special Section, three case studies are described in detail; the first deals with the development of instrumented pipe inspection gauge, the second with the development of antennae, and the third with the development of carbon fibres and shape memory alloys. Significant academic input has gone into these developments.

Epilogue

The decision to start the BARC Training School and provide academic recognition to the training programme under the umbrella of HBNI has been successful as observed by many. For example, Dasannacharya⁹, a graduate of the first batch, on completion of 50 years of the Training School, writes that ‘this has been one of the most successful training programmes in the country’. Continuing he says ‘Today, India is fully competent in all aspects regarding the needs of nuclear science, technology and their applications, largely due to those trained under this scheme.’ Graduates of the Training School have contributed to the programmes of atomic energy, and also to ‘several other major scientific and technological efforts outside the ambit of atomic energy’¹⁰.

HEIs are set up by the Department of Education, MoE, GoI, or by the State Governments. However, many HEIs have been set up by other Departments of GoI as well⁵.

All such HEIs cater to niche areas. This is indicative of the fact that the university system in the country has serious limitations in addressing the research and education needs of these Departments. One reason for this gap is the need for capital-intensive infrastructure and complex experimental facilities that cannot be set up or maintained in a typical university ambience. The universities in India also have a relatively small size of faculty, which does not enable them to cater to the interdisciplinary nature of many niche areas of education and research. The value system in the universities places the number of publications and citations thereof at a higher pedestal than the development of products and processes, which is another contributing factor.

DAE is a mission-oriented organization, that is, it is a client of the research and development done in its R&D Centres. It has to carry out a range of activities involving academic research, post-academic research and deployment. For the development of new reactor systems and associated fuel-cycle technologies, a wide range of inputs must come from academic research. Considering the intertwining of academic and post-academic research, it is best to carry them in the same organization or closely coupled organizations. A university setting can be efficient in conducting academic research relevant to a mission and that was the motivation for setting up HBNI.

HBNI has brought research activities of DAE R&D units and the GIA Institutions together, and this has resulted in their consolidation and expansion. The growth story of the academic and research programmes of the institutions of HBNI is evident; for instance, the Nature Index 2018 Rising Stars supplement lists HBNI among the institutions that have sprinted from the starting block. Nature Index 2021 ranks HBNI at 15 among global institutions aged 50 or under, and in India, HBNI ranks second with IISc at number 1 and TIFR at number 3.

Banerjee¹¹ has opined that DAE could explore the option of supporting strong centres of education and specialized nuclear research in HEIs. As explained, the alternate option of supporting an existing HEI would require huge investments in creating research infrastructure and recruiting faculty that is already available within DAE.

In the present stage of development of science and technology, the size and cost of experimental facilities are increasing, and constructing, running and maintaining facilities require well-trained manpower, which is available in large national laboratories. This kind of manpower is not available in HEIs in India and also in several other countries. One way to address this gap is to cluster national laboratories and universities as has been done in the case of the Paris–Saclay University or Caltech–JPL cluster, or to create a system like HBNI where functions of a university and national laboratory are combined in the same entity.

From its inception, DAE has been contributing to education and research in India in various ways. Setting up of HBNI has significantly enhanced contributions to education far beyond DAE. In TMC, postgraduate and super-speciality

medical education programmes have been significantly expanded and several new programmes have been started. In BARC also, skill-based programmes like M.Sc. in hospital radiopharmacy have been started; Diploma in Radiation Protection has been converted to an M.Sc. programme at NISER.

Statistics indicate that several alumni of HBNI have taken up faculty positions in various educational institutions in India. This underlines the fact that instead of depleting the university system in the country, the human resource development in DAE is strengthening the system.

Emphasis by Bhabha on growing people capable of tackling tasks that lie ahead has yielded rich dividends and made India self-sufficient in nuclear science and technology. DAE continues to enhance its contribution to science and technology in various ways, including education in HBNI.

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