

Project Outline

**NATIONAL INITIATIVE ON UNDERGRADUATE SCIENCE
(NIUS)**

Project Proposal by HBCSE (TIFR)

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NATIONAL INITIATIVE ON UNDERGRADUATE SCIENCE

1. Introduction

National Initiative on Undergraduate Science (NIUS) is a major proposal of HBCSE (TIFR) addressed to two key issues concerning tertiary science education in India. These two issues are:

- *Declining number of meritorious students for B.Sc./M.Sc. courses*

A great majority of meritorious science students of the senior secondary stage (the 'plus two' stage) opt for professional careers in engineering, medicine, computer science and allied fields. There are very few takers among them for the basic science streams leading to B.Sc and M.Sc degrees in different subjects. For example, of the 100 students who represented India in the International Science and Mathematics Olympiads in the last five years or so, something like 8 students may have opted for basic science.

- *Lack of academic excitement and motivation in B.Sc. programmes*

With some honourable exceptions (a few colleges in metropolitan areas) undergraduate colleges in India offer little challenge and excitement in science to their students. The B.Sc stage is the most vital stage for stimulating genuine interest in science and triggering fascination for a research career. Unfortunately, the overwhelming majority of B.Sc students, even those with considerable talent, go through it without any serious motivation, and mainly orient themselves entirely to the examination. By the time they come out of their degree programmes, most of them (including good students) lose interest in pursuing research careers.

Two observations are important in this connection:

- i) There is a prevalent assumption that 'all' those who are any good go to IIT's, medical institutes and the like, and those that are 'left out' join science colleges. Experience shows that this picture is only approximately true. Actually, undergraduate science colleges in India do have a small (as a fraction) but significant (in terms of absolute numbers) population of good and motivated students who aspire to do well in basic science careers. A fraction of this small minority of students has actually opted for basic sciences out of genuine interest, even though they had an option to go for professional degrees.
- ii) Many of the meritorious students, especially from the Olympiad stream, have in fact genuine interest in pursuing studies in basic sciences or mathematics, even though they may have made the 'pragmatic' choice of going in for professional degrees. Experience over the last several years shows that several of such bright students look for opportunities to learn basic sciences through special enrichment programmes wherever they can find them. In fact, some of them (undoubtedly, very few) have returned or at least contemplate to return to their original subject of interest after they complete their professional degrees.

These observations suggest that, broadly speaking, two groups of tertiary stage (i.e. post senior secondary stage) students in our country would greatly benefit from a sustained and intensive nurture programme; one, the highly motivated students pursuing science degrees in undergraduate colleges, two, the post-olympiad (and equivalent) students pursuing professional degrees in IITs, premier medical colleges, etc. The present proposal has been formulated basically with these two target groups in mind.

2. Need for a strong nurture programme at undergraduate stage

The need for undergraduate nurture programmes is widely appreciated in the country. The general feeling shared by most scientists is that something needs to be done urgently to attract and nurture good undergraduate students to sciences, to secure the future of science in India. Indeed, several leading institutions in the country (IISc, RRI, SINP, TIFR, JNCASR to name a few) have already taken steps to avert the problem and are offering summer programmes, student visitorships, etc, to motivate bright young students to research careers in sciences. In mathematics, NBHM has been successfully co-ordinating nurture programmes in mathematics for many years.

The underlying aim of NIUS is thus not new. Where it differs is in the scale, intensity and coverage of the programme. NIUS is conceived to be a large scale, comprehensive and sustained programme, encompassing all basic sciences, including mathematics. It will have several components; selection of students on an all-India basis (using the current Olympiad and KVPY schemes as also new nationwide testing schemes, if necessary); summer and winter nurture camps in theory, problem-solving and experiment; a strong programme of undergraduate student research with special emphasis on experimental research / instrumentation development, etc; joint resource generation camps of scientists and college teachers, and a distance education programme to keep students in continual contact with their research mentors. In short, NIUS is a major new national initiative on undergraduate science that focuses on early nurture of potential Indian scientists of the future.

3. National Initiative on Undergraduate Science – A joint TIFR-BARC initiative co-ordinated by HBCSE

Though ambitious, NIUS is a realistic and feasible proposal and HBCSE is ideally positioned to be the nucleus of the programme and to co-ordinate it in view of the following observations:

1) Experience with the Olympiads

NIUS is a natural sequel to the Olympiad programme spearheaded by HBCSE in the last 5-6 years. HBCSE is now the nodal centre of the country for Olympiad activity in 5 subjects : physics, chemistry, biology, mathematics and astronomy. Each subject has a small but dedicated cell where members are devoted full time to the programme and have developed considerable expertise in carrying it out efficiently. These Olympiad cells of HBCSE with some augmentation (that is expected in the near future) will play the co-ordinating role for the new initiative on undergraduate science. The Olympiad cells of HBCSE will be supported by the administrative staff of HBCSE who already have much organisational experience in conducting programmes of the kind envisaged.

2) Academic support from TIFR, BARC and other institutions

The scale and scope of the programme would need tremendous academic resource mobilization by HBCSE. But this is feasible because of the institutional links of HBCSE with TIFR and BARC and the large pool of high quality scientific manpower available there. HBCSE will also seek help from individual scientists from other leading institutions in the country such as IISc., IITs, etc. as also from local institutions in Mumbai and the

neighbouring city of Pune such as IIT Bombay, UIT, University of Mumbai, University of Pune, NCL, etc. **However, the core academic co-ordination of the programme, as also its organizational aspects, will be the responsibility of HBCSE.**

NIUS is thus best viewed as a joint academic initiative of TIFR and BARC, which will be coordinated and implemented by HBCSE (TIFR). A strong synergy between different institutions is, therefore, inherent in the proposal. In particular, the laboratory facilities, instrumentation set-ups, workshops, etc., as also the large pool of scientific expertise in these institutions, will be used extensively to implement NIUS (after working out the necessary modalities for the same).

3) *Infrastructure*

The Olympiad block of HBCSE and the main building which house the Olympiad laboratories in chemistry and biology would be suitably equipped for the NIUS programme. However, the Olympiad block had to be accommodated within a rather narrow space adjacent to the HBCSE hostel. Consequently, the space for physics, astronomy and instrumentation laboratories and a workshop will continue to be inadequate even in the Olympiad block. Thus an extension of the Olympiad block is absolutely necessary to conduct satisfactorily the experimental programmes and classroom sessions of all the five Olympiads. This need is even more acute for NIUS for developing advanced facilities suitable for tertiary science programmes including research by undergraduate students. Another most important critical element of infrastructure missing at present is an adequate hostel accommodation for visiting students.

In view of these infrastructure needs, the budgetary proposal incorporates a plan for building a new Laboratory Block and a new Student Hostel on the land just behind and contiguous to HBCSE hostel. Without this additional infrastructure, NIUS will remain a local and sub-critical effort and it will not be possible to implement it.

4. **NIUS – Outline of the scheme**

NIUS is planned to be a comprehensive new interventional programme at the tertiary stage of science education, with all-India coverage. A brief outline of the scheme is as follows:

a) *Selection of students for NIUS*

- (i) A selection procedure will be formulated to search and identify meritorious students in undergraduate science colleges in India. About 100 students will be so identified every year from the different disciplines of basic science, including mathematics. For the year 2004 the selection will be based on KVPY, JBNSTS, and allied criteria. Proactive efforts will be made to see that bright and motivated students in non-metropolitan areas do not miss out the opportunities made available by NIUS.
- (ii) The National Olympiad Gold Medallists in different subjects will automatically qualify for selection under NIUS. This group (which will be mostly pursuing professional courses at IITs, etc) will also be about 100 in number.

All together, taking into account some drop-out, NIUS will have about 150 students (about 35-40 students each in say physics, chemistry, biology, mathematics) in the first year. The nurture programme for every student will run for about 2 years, with possible

spill-over to the 3rd year to complete the research report. This means that in a few years, we expect to have about 400 students at any given time in different stages of NIUS.

The infrastructure (NIUS labs and the new Student hostel) is likely to be functional only from April 2006. However, HBCSE has launched the programme from April 2004. The NIUS student strength is expected to progressively increase from 75 (2004-05) to 150 (05-06), 225 (06-07) and achieve its steady strength thereafter.

b) *Nurture Camps at HBCSE (TIFR)*

Every student under NIUS will go through 4 nurture camps in 2 years (2 camps in the summer and 2 camps in the winter). A spill over to the third year is expected for a majority of students to complete their research reports. The nurture programmes will be carefully formulated by the respective cells of HBCSE in consultation with the scientists involved in the programme. The camps will include theoretical lectures, problem-solving sessions, laboratory sessions, student seminars, etc. The nurture programme will be calibrated to the extent possible in accordance with the interest and potential of the student – blanket uniformity will not be stressed. An important dimension of the programme is to promote proto research among students. Undergraduate students will be encouraged to take up investigative theoretical and experimental research projects. It is here that the help of scientists from TIFR, BARC and elsewhere would be particularly critical. Typically, students will go through training and background preparation for research in the first year of nurture, take up research under the guidance of their mentors in the second year, and complete their research reports at most by the end of the third year.

c) *Distance Education*

A key element of NIUS that may set it apart from other similar programmes is its stress on continual contact with the selected students through postal correspondence and internet. This again will be calibrated as per the students' needs and no uniform postal tuition programme is envisaged. For research, particularly the experimental research, the institutes in the neighbourhood of the student's base station may also be liaised with where appropriate.

d) *Joint resource generation camps of scientists and teachers*

Besides nurturing talented students, an equally important objective of NIUS is to partner with competent college teachers in science across the country. Special efforts will be made to enlist the participation of motivated teachers from non-metropolitan areas. Two joint resource generation camps in each subject will be held at the HBCSE every year. In these camps, scientists and teachers would work together to design new problems, develop new experiments and instrumentation set-ups and formulate ideas for student research projects. This partnership of scientists and teachers would expand the outreach of NIUS even to students not selected under NIUS, and will thus ensure a multiplier effect of the programme.

e) *Co-ordination of a forum of NIUS scientists and research mentors.*

Implementing the different components of NIUS indicated above will be a highly demanding task. As already mentioned, HBCSE, even with some additional staff strength, can handle this only because of the assured help from the TIFR and BARC, augmented by support from scientists from other institutions. To nurture the substantial number of NIUS students, an NIUS forum of 30-40 scientists will be identified from these institutions, with each scientist committed to the programme for at least 2 years. Thus we will enlist help from something like 7-8 scientists in each of the four basic science

disciplines (physics, chemistry, biology, mathematics). As explained earlier, for practical convenience, most of them are likely to come locally from TIFR, BARC and other institutions in the city, or from the neighbouring city of Pune. Some will be enlisted from elsewhere in the country. Part of this resource mobilization will be carried out by expanding the present HBCSE provision of visitorships to scientists and teachers. A large number of scientists have already offered help for NIUS and several of them participated actively in the first NIUS nurture camp held at the HBCSE from April 27 to May 15, 2004.

Each scientist of the forum will be associated with a few NIUS students for guiding research. But the scientists of the forum would be spared from all organizational and co-ordination work of NIUS, which would be the responsibility of HBCSE. The HBCSE Olympiad Cells would carry out the selection of students, develop problem materials and laboratories for nurture camps, mediate distance education programme and in general co-ordinate the entire academic work. The administrative staff of HBCSE would look after the organizational aspects of NIUS.

f) *Student Research Reports*

A tangible and specific expected outcome of NIUS would be a substantial number of research reports every year brought out by undergraduate students under the guidance of their research mentors. The quality of these research reports will be an important measure of the success of NIUS programme. Emphasis will be on producing research that is publishable as a paper or a review in a standard international journal. Design and development of innovative advanced experiments / theoretical problems / computer based learning materials, etc., that are publishable in reputed science education journals will also qualify as research reports. Students will be encouraged to develop indigenous characterisation / diagnostic tools and instruments.

g) *Local Study Circles*

HBCSE's Olympiad Cells will initiate local Study Circles for the undergraduate college students of Mumbai. The students of these Study Circles will not necessarily be the selected NIUS students. The Study Circles will involve intensive weekly academic sessions for interested undergraduate students. Unlike NIUS, there will be no selection involved for attending the Study Circles, and there will be no financial incentives to the students. The selection will be built-in; those who do not like the proceedings will drop out. A Physics Study Circle of this kind ran at HBCSE for 13 years with much success. As a first step under NIUS, a physics study circle has been launched in December 2003.

Analogous to the local Study Circles, local Teacher Circles are also being initiated wherein college teachers meet regularly once every month for academic work such as designing questions and problems, developing new ideas for experiments, etc.

Though not directly a part of NIUS, local Study Circles and Teacher Circles are immensely important, in that they would help generate and sustain an intense academic activity at HBCSE throughout the year which would, in turn, be important for all the components of NIUS.

h) *Incentives to NIUS students*

No scholarship/student fellowship is envisaged for NIUS students at present. Some of the NIUS students are likely to be Kishore Vaigyanik Protsahan Yojna Fellows and will anyway get the benefits associated with KVPY. Each NIUS student may, however, get a contingency grant of Rs.5000/- per year, for purchase of books/educational CDs and visits to different institutions in the country.

Apart from nurture camps at HBCSE Mumbai, an integral part of NIUS will be to expose the undergraduate students to the premier research institutions in the country and to the work that is going on there. Every student of NIUS will be encouraged to visit at least half a dozen institutes in 2 or 3 years. Such visits have a deep impression on young students and inspire and motivate them to work. NIUS students from non-metropolitan areas who need such exposure more than others will be given special attention in this regard. Financial support for promoting these visits will be part of the contingency grant to each student.

5. Steering NIUS

A Steering Committee chaired by Director TIFR will need to be set up to oversee the programme. On the Committee may be scientists from BARC, TIFR main campus, NCRA, NCBS, HBCSE and other institutions in Mumbai and elsewhere; as also the representatives of the Departments of the Govt. of India involved in the programme.

6. Conclusion

We believe NIUS of the kind outlined above is a critical and pressing need of students in the tertiary science education sector of the country. As a TIFR-BARC initiative coordinated by HBCSE, it is also a feasible programme. It should be noted that NIUS is not an undergraduate science degree programme. It does not aim to start a new 'elitist' undergraduate college for the brightest. Rather, it is an interventional programme in the mainstream, aiming to reach the motivated students from every part of the country (metropolitan or otherwise) and give them the benefit of intensive contact with some of the best scientists and teachers of the country. In this sense NIUS promotes both equity and excellence - the twin values guiding HBCSE (TIFR)'s work. Its main mission in the long run is to feed high quality students to TIFR, BARC and other leading scientific institutions and universities in the country for their more advanced educational and research programmes.



HOMI BHABHA CENTRE FOR SCIENCE EDUCATION

NIUS Project Summary

Objectives

- i) To carry out an intensive and sustained nurture programme in basic sciences (including mathematics) for talented undergraduate students selected annually from across the country.
- ii) To take affirmative action, as part of NIUS, to nurture undergraduate college students especially from non-metropolitan parts of the country.
- iii) To make proactive effort, as part of NIUS, to encourage national Olympiad medallists and similar outstanding students to sustain their interest in basic sciences, despite their entry to professional courses in engineering, medicine, etc.
- iv) To promote and catalyze **undergraduate student research** in basic sciences, with strong emphasis on experimental research/instrumentation development, etc; and to develop suitable laboratories for the purpose.
- v) To partner with motivated college teachers, especially from non-metropolitan areas, in implementing the aims of NIUS and thus ensure multiplier effect of the programme. This will be done through periodic resource generation camps to be held at HBCSE at different times of the year where scientists and college teachers would come together.
- vi) To initiate and co-ordinate an active forum of interested scientists and university teachers, especially from TIFR and BARC (in view of their vicinity to HBCSE), who would volunteer to provide academic support to HBCSE as nurture camp faculty and research mentors.

Expected output

1. Each selected student will go through 2 years of nurture involving 4 nurture camps at HBCSE (in summer and winter), with possible spillover to the third year to complete his/her research report. At its full strength, NIUS will select about 150 students from across the country each year, so that about 400 students will be involved in different stages of NIUS at any given time. **Thus NIUS will help a significant number of talented undergraduates of the country attain higher core competencies and go through a unique experience of research and development in their subjects.**

In the first year of the programme (2004-05) launched already, about 75 students in all have been selected. This number will be upgraded to 150 per year as mentioned above, as soon as the required infrastructure (Laboratory Block and Student Hostel) is ready.

2. A major tangible output of NIUS will be the bringing out of a substantial number of quality research reports by undergraduate science students in India. A research report may be a research paper in a professional journal or a good review of some theoretical/experimental topic, or a new experimental (instrumentation) set-up at the HBCSE laboratories, etc.
3. An equally important output will be the generation of academic resources (design of challenging problems, development of novel experiments, instrumentation set-ups, etc.) jointly by scientists and college teachers at the periodic resource generation camps to be

held at HCBSE, at different times of the year. The participation of teachers will ensure a multiplier effect of the programme and expand its outreach throughout the country.

4. All these outcomes will effect a significant improvement in input quality of future scientists to the national laboratories, universities and other scientific institutions in the country.

Remarks

- * NIUS is not a degree programme; it is simply an all India talent nurture programme with emphasis on undergraduate student research.
- * NIUS does not entail any scholarships for students. A contingency grant for books is, however, included in the proposal to facilitate student research.
- * NIUS is not a programme of 'summer attachment' of students to different research institutions in the country. With some exceptions, all research and development work of students would be coordinated by HCBSE, with active help of scientists, especially from BARC and TIFR.

Major Benefits

- 1) At its full strength (which will be achieved when the proposed new Laboratory Block and Student Hostel are ready) about 400 undergraduate students from all over the country would be going through different stages of NIUS. Thus NIUS will directly help in improving core competencies of significant number of promising Indian students in basic sciences including mathematics, and in catalyzing undergraduate student research in India.
- 2) The joint NIUS resource generation camps of scientists and teachers, to be held periodically at HCBSE, would lead to enhanced professional competence among significant number of motivated college teachers, especially from non-metropolitan areas. This partnership of scientists and teachers would expand the outreach of NIUS even to students not selected under NIUS, and will thus ensure a multiplier effect of the programme.
- 3) These gains will result in a few years in a marked improvement in quality, preparation and motivation of new entrants to TIFR, BARC, other national laboratories of DAE, as also other scientific institutions and universities of the country.

In short, NIUS is expected to be a major beneficial intervention of DAE through HCBSE (TIFR) at the critical undergraduate stage of science education, which will complement other major initiatives on general improvement of college science education being taken up by UGC and other concerned Departments of the Central and State Governments.

