

**Report of the review committee on
Homi Bhabha Centre for Science Education, Mumbai
(December 20, 2014)**

Composition of the committee

The committee consisting of

Professor N. Sathyamurthy, Director, IISER Mohali,
Dr. G. P. Phondke, Former Director, NISCAIR, New Delhi,
Professor T. S. Saraswathi, Retired Professor, M. S. University, Baroda,
Professor Jill Adler, First Rand Foundation Mathematics Education Chair, University of Witwatersrand, South Africa,
Professor Sibel Erduran, Professor of STEM Education, Director, National Centre for Excellence in Mathematics and Science Teaching and Learning, and Director, International History, Philosophy and Science Teaching Group Council, University of Limerick, Ireland and
Professor Paula R. L. Heron. Professor, Physics Education, University of Washington, Seattle, USA
visited the Homi Bhabha Centre for Science Education (HBCSE), Mumbai during Oct. 19-21, 2014.

The detailed programme of the meeting of the committee with the Director, TIFR, Mumbai and the Director, HBCSE, Mumbai and other officials and members of HBCSE is given in Appendix A.

Detailed presentations were made by various members of HBCSE on the history of HBCSE since its inception and the marks made by it in the field of Science Education, Olympiads and the recent National Initiative on Undergraduate Science (NIUS).

Introduction and background

The Centre was set up initially to reach out and help the underprivileged students towards science education. In the last four decades the centre has done a commendable job. It has produced a large number of books and other science education materials for primary school, high school and higher secondary school. The work done by the centre towards science education and mathematical education has put India on the world map. Some of the papers presented in international conferences on science education and papers published in international journals in science (physics, chemistry, biology and maths) education, especially the epiSTEME seem to have received considerable attention.

The faculty and staff of the centre are fully involved in science education, popularization of science and producing print and audio and video material on science education in different languages, including English, Hindi and Marathi. A centre that started off in one floor of a Municipal School has done a remarkable job in making a difference in Science Education in the last four decades.

The committee was impressed with the total commitment shown by all sections of the centre. This includes the administrative and other staff. Some of them pointed out that they undertake multiple tasks and work beyond scheduled hours to make sure that the time bound activities such as Olympiads are on schedule.

The report that follows addresses each dimension of the Centre separately in the first half followed by recommendations for the Centre's development as a whole.

Science, Technology, Mathematics Education

It is noteworthy that a large number of books and other educational materials have been produced by the Science, Technology, and Mathematics Education (STME) faculty. While the sale of books by the centre can be a good measure of their popularity and use, these books and related materials have not been reviewed by independent professionals, which could help ensure high quality and extend their impact.

The Centre's work is not as well known in the country as it ought to be. Many good schools and teachers in mathematics and science do not seem to have heard about the Centre and its work. In addition to working with Apex bodies, the Centre should promote its work through different media to let people know about it. The materials developed by the centre need to be copy righted and any adaptation rightfully acknowledged by the users.

Here one must add that the Mathematics group stands out as an excellent exemplar of what the Centre should be doing and how. It was evident from the Figure in the little booklet that was handed out by the Maths group. This group seems to best meet the objectives of equity, outreach, dissemination and convergence. Some of them have taken Indian culture seriously; they focus their work on the children in disadvantaged communities, and are excited about their work and have a clear identity. This seems to be missing in some of the other thrust areas.

Science (and mathematics) education is not simply teaching science (or mathematics) to students; it involves understanding the children's mind and the necessary pedagogic approach to teaching science (or mathematics) to children in various age groups and to train the trainers in science (or mathematics) education.

Indeed there are formalised academic disciplines called "science education" and "mathematics education" each of which is a research-based approach to science and mathematics education from a range of theoretical and methodological approaches. Science and Mathematics Education as disciplines have their own international organisations (e.g. ESERA, ICMI, CERME) and their own research dissemination venues (e.g. Journals such as *International Journal of Science Education* and *Journal of Research in Science Teaching; Educational Studies in Mathematics and the Journal for Research in Mathematics Education*); and there are some journals that disseminate both mathematics and science education research (e.g. *International Journal of Science and Mathematics Education*). Science and mathematics education researchers at HBCSE have contributed to this aspect of science and mathematics education in important ways, providing a presence for India in the international community. For example, they have published in *the International Journal of Science Education*, and in *Educational Studies in Mathematics*

and participated in international conferences such as NARST and IGPME annual conferences. Continuation of the science and mathematics education research mission of the centre is paramount to maintaining and enhancing a research and evidence-based approach to the science and mathematics teaching and learning aspirations of HBCSE.

epiSTEME

The epiSTEME meets have brought together eminent scholars in the areas of science, technology and maths education and social scientists and made an invaluable contribution to the literature in the field through edited volumes. These volumes have found worldwide recognition and are used widely. This conference series should be continued.

OLYMPIADS

In the last two decades the centre has trained a number of students for international (physics, chemistry, biology, astronomy and mathematics) Olympiads. While the first round of screening is done by the Indian Association of Physics Teachers, Association of Chemistry Teachers and Association of Teachers in Biological Sciences, the second round of examinations is conducted by the centre. That is followed by a training of the selected students in theory and experiment, short listing of 4-5 students, training them further and accompanying them to the Olympiads in each subject, wherever they are held globally. Invariably, the students have brought Gold, Silver and/or Bronze medals and done India proud. A number of medallists have gone on to pursue science as their career.

The international Olympiads bring in international standards at the pre-university level. The process of selection and training of the students has, naturally, remained at the global level. The staff members involved in the Olympiads work throughout the year, preparing new questions, designing new experiments and mentoring the students. While this is commendable, these inputs seem to remain within the restricted circle of Olympiad candidates. The Centre should take active steps to propagate these to the wider community which could go a long way in improving undergraduate education. Here one must mention that a large number of faculty members from various institutes have contributed to and benefited immensely by participating in the training of the students over the years. The centre has done a commendable job in hosting the International Chemistry Olympiad in 2001, biology Olympiad in 2008 and is gearing up to host the physics Olympiad in 2015.

The Olympiad cell has done a commendable job in training students towards Olympiads. When one batch of students returns to India with various medals, the work for the next round of Olympiads is initiated. Since this is a time bound activity, it is important to remove mundane work from the hands of the faculty. It became quite clear to the committee that the workload of the Olympiad programme is causing considerable strain on the existing manpower. While efforts for augmenting the same should continue, the committee realises that there may be certain constraints beyond the control of Centre's management. It is also evident that intellectual inputs of the staff engaged in the programme are limited to a few of the involved activities. Considerable time and energy is spent on routine logistics management.

NIUS

With the purpose of following up on the performance of the medallists and to encourage students to pursue science research, a National Initiative for Undergraduate Science (NIUS) was undertaken by the centre a few years ago. A good beginning has been made and the centre has been able to identify a number of bright students in science and engineering and nurture their interest in science by enabling them to work with mentors in various academic institutions in the country. While the investment in Olympiads training yields visible returns in the form of medals, the NIUS programme has reaped rich dividends in the form of research publications by undergraduates. It ensures that some of the potential scientists of the country are identified and mentored in the right direction.

Doctoral Programme

In addition to STME, Olympiads and NIUS activities, the faculty at the centre have been guiding PhD students. Although there are 17 faculty members, only a small fraction of them seems to be guiding PhD students. A large number of PhD scholars seem to spend 2 years in course work and then look for suitable research problems in the area of science education for their theses. There did not seem to be a shared vision among the faculty about how to guide students in choosing thesis topics. Different students seem to be pursuing different problems without interacting with each other and without any focus. Some of the early doctoral graduates from the centre have stayed on as faculty at HBCSE and actively participated in Olympiads and NIUS. The doctorates in recent years have struggled to find suitable positions. The Centre seems to be (justifiably) reluctant to hire its own graduates, but there are few other Centres, Institutes or academic institutions where their expertise is equally well suited.

The presence of doctoral students is critical for the development of the centre, both in house and outside. The graduates will be brand ambassadors, who will spread their wings and evolve a network of peers. Many PhD students at the centre seem to be frustrated because they seem to spend about 2 years doing course work and then choose their thesis topics randomly without any coordination. This makes the job of the students and the faculty difficult and results in a scattered knowledge base that does not accrue. Over the coming years, the centre should become known for its expertise in and contribution to specific areas of work.

The Centre as a Whole

While India has done an excellent job in education by producing bachelors and masters in education degree holders (B Ed and M Ed), it has lagged behind in science education. HBCSE can, in principle, fill this gap by producing BSc Ed and MSc Ed graduates, who will go on to educate school children in science and mathematics.

Over the years, the centre has come up with the main building focusing on STME and separate buildings for Olympiads and NIUS. Unfortunately, such a creation of infrastructure seems to have developed three separate entities in the centre. While the faculty responsible for Olympiads and the faculty responsible for NIUS seem to interact with each other, there seems to be a clear separation from the STME faculty. This is clearly

not in the larger interest of the centre. It is important for the entire faculty to work together in a seamless manner. The STME faculty could participate in conducting Olympiads and in undertaking research on Olympiads and NIUS. The faculty dealing with Olympiads and NIUS could participate in science education research and guide research scholars. Such an approach would lead to a win-win situation for all the stake holders of the Centre.

Recommendations

After listening to detailed presentations by various faculty, staff and students of the centre and intense discussions with them during the three days of the visit, the committee would like to make the following recommendations:

- **OLYMPIADS:** It appears that funds for the Olympiad programme are specifically earmarked for it. Even so, for administrative reasons, they are routed through the existing channels of HBCSE. This is appropriate for proper accounting purposes and perhaps to maintain RTI compliance. Nonetheless, this creates certain problems at the operational level and can cause avoidable friction. It is, therefore, recommended that a certain degree of functional and financial autonomy be accorded to the Olympiad programme, which would facilitate greater work efficiency. Periodical internal audit can ensure that the autonomy is properly exercised.
- It is important for the Olympiad team to ensure continued commitment to quality. This requires that the faculty do not dissipate their energy in Asian Science Olympiads, Junior Science Olympiads, etc. and remain focused on the five international Olympiads (mathematics, physics, chemistry, biology and astronomy).
- The Faculty in the Olympiads cell need to interact more with the STME faculty. This will help them improve their preparation for the Olympiads year after year. Those engaged in the Olympiad movement can undertake novel research programmes with the help of PhD students in STME to test and develop innovative ideas.
- **NIUS:** The centre must have a rethink on NIUS. While it is commendable that the Centre is keen to ensure that the Olympiad medallists are not lost from science, the centre must not undertake tasks which are not really its. Particularly with an increase in the awareness of undergraduate research in the country in general and in IISERs, NISER and IITs in particular, the centre must rethink about NIUS related activities. It may be a good idea to undertake an impact assessment beyond the number of publications by the undergraduate students under NIUS.
- **STME:** There could be greater co-ordination between STME and Olympiad wings with a two way process of participation. STME can make significant contributions to the Olympiad programme and vice versa. This should not only be congenial for harmonious relationship but also for raising the standards of all. To start with, STME faculty can undertake an evaluation of the grass root impact of the Olympiad movement. This could form the subject matter of some of the PhD theses in STME.

- **Faculty:** The faculty at HBCSE seem to be publishing reasonably well. While it is important to publish in international journals, they must also publish in some of the Indian journals to increase awareness among the Indian colleagues and students. The centre must come up with ways and means of collaborating with neighbouring institutes.
- During the deliberations with the faculty it became clear that they are talking as individuals, taking care of individual cells and talking about individual growth. The centre must strive hard to make the faculty talk about the growth of the centre collectively. It would be in the larger interest of the institute to have a shared agenda among the faculty. Mutually beneficial collaborations among the various members of the centre would benefit the overall ambitions of the centre. Collaborations will need to be creative in pushing conventional boundaries in setting up exclusive agendas. Examples of potential collaboration include the infusion of more research based approaches facilitated by the STME staff in the Olympiad program.
- There seems to be a need for a mentoring mechanism for the 17 faculty members; 4 of them (including the Director and the Dean) would retire soon. Already there are 7 vacancies. While this could be alarming, this would also provide an opportunity to attract bright young minds involved in science education to the faculty of HBCSE. A critical mass is essential for the faculty as well as PhD scholars in the Centre to achieve realistic goals.
- Discussions with the faculty revealed that there is a need for a greater dialog between the faculty and the management. It is important for the latter to specify the criteria for promotion/ appointment at higher levels and to make the functioning of the institute transparent. This will build confidence of the faculty in the institute.
- **Doctoral Programme:** Some of the PhD students take more than 7 years to submit their theses. The fact that the career progression of PhD scholars of HBCSE is not clear adds to their frustration. The nomenclature of the degree seems to be a deterrent in job placement. The term Mathematics is not included in the degree certificate, which says only Science Education and a doctoral degree in STME is not considered equivalent to M.Ed., thus closing the doors of employment in teacher training institutions. This is an anomaly considering the objectives of the Centre. Since the education system in India is rigid, the only way to penetrate into it is through effective and persistent lobbying to find acceptance and recognition. This has to be done.
- The curriculum for the PhD scholars at the Centre could be revised to facilitate a more coherent coursework for students, and the time they spend on this (maximum 18 months). The program should be unique and must realize the potential of the scholars committed to science education. Given the inherent inter-disciplinary nature of science (including mathematics) education research, it could be helpful to structure the curriculum to include a study of four areas, and their inter-relations: Educational theory and philosophy of science; Research methods in educational research; Science/mathematics education and Science/mathematics content.

- Therefore, it is important for the centre to clearly identify the courses needed for its PhD students and enable them to take some of the courses elsewhere (for example, in Mumbai University, IIT Bombay and Tata Institute of Social Sciences). The curriculum needs to be developed on advanced science as well as on advanced science education. They seem to need a course on scientific writing too! There is some merit in their desire to do some of their field work outside Mumbai. It may be a good idea to have some of the faculty from other institutes as adjunct faculty of the centre to contribute to the growth of the PhD program. There is a need for mentoring of the scholars and inculcating a sense of belonging in them.
- The requirement that students publish in an international journal prior to graduation seems to be a barrier for some students, not because they are unable to produce papers of appropriate quality, but because the time-frame (possibly 18 months or more between submission and publication in some journals) requires submission very early in their research project. The Centre should examine how to maintain standards while reducing this burden.
- The centre may allow those with an M Ed degree to join the PhD (Science Education) program. It may also help in the preparation of the material for BScEd and MScEd degrees, wherever applicable. It may like to lobby for some of the BED and MEd programs in the country to specialize in science education and for inclusion of PhD (Science Education) for jobs in many higher secondary schools and other academic institutions.
- The work of the subcommittee set up to examine the students' concerns must be followed up in a time bound manner in consultation with the students or their representatives. Many of their concerns seem to be genuine and they should be addressed at the earliest. This will benefit the Centre in many ways.
- **Staff:** HBCSE is a unit of TIFR. It is but natural and just that the basic policies of staff promotion dependent on evaluation of their performance followed in TIFR would be applicable to the staff in HBCSE. However, the nature of work carried out in HBCSE is distinctly different from that in TIFR. Therefore, the criteria for assessing candidates cannot be identical in the two places. The principles underlying evaluation criteria for the centre should therefore be established in the spirit in which they are instituted in the parent organisation and not literally verbatim. In particular, the nature of research in science and mathematics education should be given due consideration in deciding these criteria. Likewise the nature of work involved in the Olympiad as well as NIUS programmes should be taken into account before criteria for evaluation of the staff engaged in these activities are set.
- **The Centre:** HBCSE must consolidate its efforts and focus on selected areas. The twin goals of promoting equity and excellence seem to be pursued independently; the Centre is encouraged to find ways for these goals to be more mutually reinforcing.
- It should not get involved in mundane work such as direct training of teachers, but should serve mainly as a think tank for science education. It must dedicate itself to

science education in a true sense. It must increase its outreach activities by working with school systems and communities. It may like to reduce in-house publishing and may like to outsource its publishing tasks and to make its education materials available through distributors.

- HBCSE is a unique institution, one of its kind in the country. This means that it runs the risk of working in isolation. Although it is a centre attached to TIFR, it is not located in an academic campus. As a result, it has very little interaction with the science and maths faculty in the country at large. In today's world, international exposure of students and faculty is essential for academic growth and achievement. PhD scholars should be encouraged to participate in international conferences. In particular, if PhD students are not eligible to participate in international Graduate Summer Schools (e.g., the ESERA Summer School), perhaps the HBCSE should consider hosting a Summer School for maths and science education PhD students in Asia. Faculty should be encouraged to visit international centres of science education and spend their sabbaticals wherever possible. The centre must encourage visits of experts from all over the world to ensure that standards at HBCSE are at par with global standards. Schemes like the individual or team Fulbright Fellowships could easily be utilised to encourage faculty movement in both directions.
- The fact that the faculty has done a commendable job over the years is evident from the fact that they are sought after by NCERT, KVPY and other such agencies. In the same vein, the Centre must also endeavour to work with academic institutions. Setting up more such centres across the country (not necessarily by TIFR) would be in the larger interest of the nation. This does not mean that clones of HBCSE are needed. Any such centre should be a part of an academic (University) campus for its successful functioning.
- The proposal of TIFR to set up a similar centre in Hyderabad is welcome, but it must ensure an umbilical relationship with the University of Hyderabad, Tata Institute of Social Sciences Hyderabad and other academic institutions in the vicinity.
- Finally, in moving forward in the coming years, the Centre must keep in mind the initial vision in establishing the Centre, namely, improving the quality of science and mathematics education among the disadvantaged communities and schools. This assumes even greater significance considering the fact that both Olympiads and NIUS, by definition, cater to the gifted and thereby are elitist in nature.

Executive Summary

- HBCSE to be a think tank for science education
- Functional and financial autonomy for the Olympiad programme
- Remain focused on the five international Olympiads (mathematics, physics, chemistry, biology and astronomy)
- Rethink on NIUS
- Faculty of the Centre to function as a whole (and not in compartments of STME, Olympiads and NIUS)

- Encourage faculty visits abroad and encourage visits of experts from all over the world
- Restructure the PhD programme; ensure completion in five years; allow MEds to join the PhD programme; increase awareness about the PhDs from HBCSE for jobs in academic institutions
- Address the concerns of the students; encourage students to participate in national and international conferences
- Address the concerns of the staff; make promotion criteria transparent and related to HBCSE
- Facilitate linkages with other academic institutions in India and abroad

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N. Sathyamurthy

Homi Bhabha Centre for Science Education (TIFR)

Schedule for External Review

Day 1 – Sunday, 19 October 2014

Sessions 1 to 3 will be open to HBCSE staff and research scholars

Venue for Session 1 to 3: V. G. Kulkarni Auditorium

10.00	Review Committee meeting with Prof. M. Barma, Director, TIFR (Main Building: Room G3)
Session 1	
10.30 to 10.45	Introduction of reviewers
10.45 to 11.15	J. Ramadas: About HBCSE
11.15 to 11.30	Questions and Discussions
11.30	Tea
Session 2	
11.45 to 13.30	Faculty presentations – Science and Mathematics Education R&D
11.45	Dean, HBCSE: Overview of R&D
12.00	Individual presentations (max. 10 min & 5 slides each)
	Sugra Chunawala: Socio cultural issues in education
	K. Subramaniam: Mathematics education
	G. Nagarjuna: Knowledge cartography
	K. K. Mishra: Educational materials in Hindi
	Jayashree Ramadas: Science education
	Jyotsna Vijapurkar: Homi Bhabha science curriculum
	Karen Haydock: STEAM Lab
	Chitra Natarajan: Design and technology education
	Sanjay Chandrasekharan: Cognitive science
13.30 to 14.30	Lunch
Session 3	
14.30 to 16.30	Faculty presentations – Olympiads and NIUS
14.30	Vijay Singh, Anwesh Mazumdar, Savita Ladage: Overview of Olympiads and NIUS
15.00	Individual presentations (max. 10 min & 5 slides each)
	Prithwijit De: Mathematical Olympiads
	B. J. Venkatachala: Mathematical Olympiads
	Aniket Sule: Astronomy Olympiads
	P. K. Joshi: Junior Science Olympiads
	Savita Ladage: Chemistry Olympiads, NIUS
	Rekha Vartak: Biology Olympiads, NIUS
	Rajesh Khaparde: Physics Olympiads, NIUS
	Anwesh Mazumdar: Physics NIUS
	Vijay Singh: Physics Olympiads, PER
16.30 to 17.00	Tea

Session 4

17.00 to 18.00

19.30

Meeting with Dean & Centre Director, Venue: Room 202

Dinner with HBCSE Faculty (Venue: HBCSE)**Day 2 –****Monday, 20 October 2014****Meetings with scientific staff, research scholars, senior admin staff; Visits to laboratories and facilities, and poster exhibitions**

09.00 to 10.00

Review Committee meeting

Session 1:

10.00

10.30

Meetings with scientific staff and research scholars (venue)

Meeting with scientific staff (Room 217: Seminar Room)

Meeting with research scholars (Room 217: Seminar Room)

Session 2:

11.00 to 12.40

12.40 to 13.30

13.30 to 15.00

15.00**Visits to laboratories and facilities**

Visits to labs and facilities (Separate schedule attached)

Lunch

Visits to labs and facilities (cont.)

Tea**Session 3:****Meetings with Senior Administration staff and former Centre Directors****Venue: Main Building, G3**

15.30 to 16.00

16.00 to 17.00

17.00 to 19.00

19.30

Meeting with Senior Administration staff (Main Building, G3)

Meeting with former Centre Directors, Arvind Kumar and H. C. Pradhan (Room 202)

Meetings with individuals (as desired by the Review Committee) (Room 202)

Review Committee depart for dinner with Director, TIFR**Day 3 –****Tuesday, 21 October 2014**

9.00 to 12.30

12.30 to 13.30

13.30 to 14.30

15.30 to 16.30

16.30 to 17.30

Review committee meetings (Committee Room / Room 202)

Meeting with faculty (Room 217: Seminar Room)

Lunch

Meeting with Centre Director and Dean (Room 202)

Meeting with Director, TIFR (Committee Room / Room 202)
