HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
TIFR, Mumbai

Highlights of Annual Report 2011-12
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I. Research & Development in Science, Technology and Mathematics Education

Research on students' visualisation of DNA structure identified persistent difficulties with 2-d representations, which were addressed using skeletal 3-d models in combination with gesture, analogy and mental simulation. Aiming for more detailed understanding of 3-d structure of DNA, low-cost colour-coded molecular models were designed and constructed. Activities are being developed in which students construct physical molecular models, use static and dynamic computer graphics, simplified 3-d models, and 2-d representations of DNA, to build their mental model of DNA structure. The cognitive role of external representations in understanding DNA structure is proposed to be investigated.

Research was initiated on designing learning contexts for facilitating the transition from qualitative to quantitative knowledge employing model-based reasoning. This study will include an investigation on the nature of knowledge restructuring during the transition from qualitative to quantitative reasoning in the context of learning science. The study is inspired and informed by the history and philosophy of science, cognitive science and science education research.

In the research on Refined Concept Mapping (RCM) for Science Education, the methodology has been extended to represent life-processes, cell-division, etc. in addition to the structure, organization of systems, anatomy, taxonomy, and so on. A primer on using RCM module for representing biology has been developed for use by teachers.

A project on outcomes of inquiry teaching at the Middle School level brought out differences in student participation and the quality of students' questions and responses in the traditional and inquiry mode. One peer-reviewed publication resulted.

A comprehensive concept inventory in rotational kinematics, a critical topic in physics, was developed for probing misconceptions, deficient understanding and eliciting ill-suited reasoning patterns in the area. The work resulted in two peer reviewed publications.

A study of difficulties in teaching and learning about evolution by reviewing textbooks and teaching methods, collecting data through questionnaires, and working with students and teachers individually and in classrooms led to conjectures about the reasons for these difficulties. A method was trialled among students and teachers of Class VI and X, and modified for introducing evolution to young students. A series of activities and experiments, and a poster exhibition were also developed and piloted.

A project has been initiated to develop experiments and activities related to plants, agriculture, and evolution. A few species of vegetables, including some from the mustard family were planted on the HBCSE campus in order to photograph, illustrate, and develop activities and experiments to be used in schools.

Research on socio-scientific issues (SSI) was continued with the development of suitable questionnaires and interview protocols, which were administered among doctoral students, pre-service teachers, mass media students and MBBS students. These presented issues based on scientific controversies/ popular newspaper articles in a context enriched format, as passages that respondents read and responded to, giving insights on students' critical reasoning about issues at the interface of science, technology and society.

As part of Science Education for Diversity (SED), a European Commission funded project with 6 participant countries, school students and teachers were surveyed for their ideas about and attitudes to science, nature of science and science careers, through questionnaires, interviews and focus group interviews as well as observation methodologies. A design based research was initiated to sensitize primary and secondary school teachers to classroom issues related to diversity of gender, class, caste, region, religion, language and disabilities. In a project on inclusive education, a review of the status of education of Students with Visual Impairments (SVI) and the use of different strategies and aids for science education was presented at the All India Association for Educational Research (**AIAER)** Conference.

In Design and Technology (D&T) in School Education, the synopsis of a PhD thesis was presented on "Investigating Students', Teachers' and Designers' Ideas about Design and Developing Design Activities for Indian Middle School Students." The study gave significant insights on how students relate structure and function of artefacts while they engage in design activities, and evidences of creativity and design decision skills in students' solutions to a real world problem. Project based learning was promoted in schools through workshops for teachers and school visits.

Research on multiplicative thinking in measurement of length and area investigates core ideas in understanding this topic in the school mathematics curriculum, for example the concepts of unit, subunit, relation between the units and measures, and the use of fraction and decimal notation. Studies of children's spontaneous ways of thinking, studies of their out-of-school knowledge related to measurement, and trial teaching are the methods adopted for study. A study relating children's out-of-school knowledge to school mathematics aims at profiling students' knowledge related to mathematics gained from participation in house-hold based income-generation activity such as tailoring, leather work, zari work, etc.

Research on developing models for in-service professional development for teachers (TPD) of mathematics at the elementary school level was continued in the context of the recommendations of National Curriculum Framework (2005) towards more learner-centred approaches.

Students and teachers from a tribal village school in Maharashtra were trained in using the OLPC (One Laptop Per Child) donated by the OLPC foundation, by a pilot program, where all the children are given OLPC to take home. A studio based learning model *Chat Activity* was introduced in Marathi, which motivated the students to use the tool and resulted in marked improvement in their literacy and numeracy skills.

At the elementary school level HBCSE collaborates with three agencies of the Government of Maharashtra: the State Council of Educational Research and Training (SCERT) which prepares the curriculum framework and the syllabus, Balbharati, which produces the textbooks and allied materials, and the Maharashtra Prathamik Shikshan Parishad (MPSP), an autonomous body which has been entrusted the implementation of Sarva Shiksha Abhiyan (SSA) programme in Maharashtra State. As part of the Science Committee, HBCSE continued to help Balbharati in reviewing and revising the assessment modules (Swadhyaya Pustika) in Science for grades V, VI, VII and VIII.

Maharashtra State is currently revising its school curriculum and syllabus in order to align with the new consensus on the approach to education represented by the National Curriculum Framework (NCF 2005). HBCSE participates in the SCERT nominated curriculum and syllabus committee for school mathematics, and plays a key role in revising the curriculum in the light of current thinking about how children learn mathematics.

The MPSP mooted handbooks at the primary and upper primary level, to consist of 120 activities mandated to be carried out at a 'Shikshanotsav' to be held in each of about 75,000 primary school in Maharashtra. MPSP requested HBCSE to conduct workshops for preparation of these activity handbooks and then to certify the handbooks for overall quality, accuracy and appropriateness. For designing the activities and preparation of handbooks HBCSE provided academic and organizational support. At the review and production stage about 10 HBCSE members worked with Balbharati and also provided expertise and support in organization of regional level resource persons' training for the Shikshanotsavs.

Collaboration with National and State agencies continued. HBCSE organised internship camps for Mumbai region students of the DST funded INSPIRE programme. HBCSE staff also participated in the INSPIRE camp held at Jagdam College, Chapra, Bihar State.

As the study centre for over a decade in Mumbai for Yashwantrao Chavan Maharashtra Open University (YCMOU), Nashik, for Post Graduation Research Programme (PGRP), HBCSE continued to hold interactive workshops for the 100 students enrolled for M.Sc., M.Com. & M. A.

HBCSE continued to work with the Maharashtra Rajya Vishwakosh Nirmiti Mandal in coordinating the committee for producing the three volumes of the encyclopedia on ‘Biology and Environment’, a reference material in Marathi language. The committee has completed about 110 articles for the Volumes.

The open educational resources developed as part of the OER4S project, were uploaded to the website (www.mkcl.org/mahadnyan), which was launched by the Chief Minister of Maharashtra State on May 5, 2011. About 200 science teachers and 200 mathematics teachers were were acquainted with the nature and potential uses of these materials through workshops.

The innovative e-learning portal for science in Hindi (http://ehindi.hbcse.tifr.res.in) was enriched with a variety of materials like e-lectures, e-books, e-questionnaires, e-glossaries, e-documentaries and illustrated e-biographies of Indian scientists. An interactive forum called Vigyan Vimarsh was started on the portal where one can put questions and the readers can post answers these questions, which are published after necessary editing.

HBCSE designed objective questions of different formats aimed at testing students' in-depth knowledge of various concepts in science and mathematics, as part of the first Proficiency Test for Class X students held by the Central Board of Secondary Education in July 2011. Prior to the actual testing, a country-wide pilot study was also carried out and HBCSE analysed the data.

HBCSE staff continued to work with Andhra Pradesh SCERT in overhauling their curriculum and conducting a workshop with teachers for writing new textbooks. Teacher training was conducted at high school and pre-university level. A staff member chaired the committee for the development of curriculum in high school mathematics in Karnataka State.

HBCSE was involved in the pedagogic review of Muktangan Exploratory Science Centre (MESC) in Pune that was carried out at the request of their funding agency, Sir Dorabji Tata Trust. Revised material for training their teachers was prepared with inputs from HBCSE staff.

A media archive for video, audio and images has been created with the collaboration of CAMP and Pandora projects. This archive allows users to annotate media for research and analysis. The platform is published at http://wetube.gnowledge.org.

A series of weekly workshops were hosted by gnowledge lab to build an SMS and Web based information system for BEST buses in the city of Mumbai. The pilot version called "ChaloBEST" (http://chalobest.in) won the first prize at a nationwide competition organized by Indian Institute of Human Settlements, Mysore called "Sankranti Transform Urban India". This project was done as a collaborative studio based initiative by the gnowledge lab in collaboration with CAMP (http://camputer.org), SPARC Systems, Tata Institute of Social Science, volunteers from Openstreet Map community in India led by Shekhar Krishnan (graduate student at MIT, Boston) and BEST (Brihanmumbai Electric Supply and Transport Undertaking).

A DST Project under the Cognitive Science Research Initiative "Developing simple model systems and experimental paradigms in cognitive science education" was initiated at HBCSE in October 2010 and will run till October 2013. As part of the project, a Biology Network group has been created to functionally network teachers, students and scientists across the country to share resources and materials, for facilitating collaborative undergraduate and post graduate research. Groups of teachers and students have been mobilized to start behavioral experiments using model systems like earthworm, fruit fly and snail.

II. Olympiad and Related Activities

The Olympiad selection procedure at HBCSE in all the six subjects (mathematics, physics, chemistry, biology, astronomy and junior science) is standardized. For science and astronomy Olympiads, it consists of two theory tests conducted all over the country with the assistance of the Indian Association of Physics Teacher (IAPT), Association of Chemistry Teachers (ACT) and Association of Teachers in Biological Sciences (ATBS). The first test, conducted in over 900 centres all over the country, has mainly objective type questions; the second test conducted at 15 centres and by HBCSE, has subjective problems, and is of high difficulty level comparable to the international Olympiads. This constitutes the Indian National (Physics / Chemistry / Biology / Astronomy / Junior Science) Olympiad Examinations (INPhO, INChO, INBO, INAO and INJSO respectively).

While the participation in the first test runs into tens of thousands (the enrollment in the year 2011, was about 43,000 in Physics, 34,000 in chemistry, 11,000 in biology, 12,000 in astronomy and 23,000 in junior science), the second test sees the participation of the top 300 students in each subject. In the next phase of selection, about forty students in each subject are selected from the Indian National Olympiad examinations and are invited for orientation-cum-selection camps held at HBCSE. Students appear for several theoretical and experimental tests, leading to the selection of Indian Teams for the final international Olympiads. The selected teams for international Olympiads again go through two weeks of pre-departure training at HBCSE. A similar pattern of selection and training is followed in mathematics under the aegis of the National Board of Higher Mathematics.

Out of the 30 student team members who represented India in the International Olympiads in Physics, Chemistry, Biology, Mathematics, Astronomy and Junior Science, 28 bagged medals and this included 11 gold medals.

Over 200 of the best students from across the nation were given experimental and theoretical training. Further, more than three hundred teachers attended resource generation and exposure camps, some from Bangladesh, Sri Lanka and Nepal.

HBCSE took a major role in the design and development of experimental and theoretical problems for The Asian Physics Olympiad to be hosted in Delhi by IAPT in May 2012. A large number of sessions involving teachers and scientists were organised for the design of challenging experimental and theoretical questions.

The Atomic Energy Educational Society (AEES) and HBCSE continue to collaborate in several areas. The junior mathematics and science olympiads camp conducted each year in May draws some of the best students of the Atomic Energy Schools from all over the country.

Since 2006, HBCSE has been a zonal centre of KVPY (Kishore Vaigyanik Protsahan Yojana), a prestigious scholarship scheme of the Govt. of India for meritorious students. Accordingly, the Centre oversaw the conduct of the Aptitude Test held in November 2011.

The Madhava Mathematics Competition (MMC) 2012 was organized by HBCSE under the aegis of NBHM for undergraduate students in mathematics. This year the programme was extended to 12 regions from 6 in the previous year.

Two nurture camps, funded by NCERT were organized for NTS awardees, in the month of February, 2012, with 60 students in each. Students from all over Maharashtra attended the camps consisting of motivational lectures and laboratory sessions.

III. National Initiative on Undergraduate Science (NIUS)

The National Initiative on Undergraduate Science was launched in the summer of 2004. Till date over 600 undergraduate students have been exposed to this programme, which includes initiating and guiding students for proto-research, preparing and editing lecture notes, and promoting undergraduate research. The programme also includes the development of theoretical and laboratory courses, R&D in science education/laboratory training and training of students and teachers in experimental science. Another aspect has been to assist college teachers in setting up modest research programs who in turn would then locally mentor students. To this end a number of college workshops and conferences have been organized.

More than a hundred and fifty undergraduate students were invited to attend extended nurture camps, of whom a fair fraction were from non-metropolitan colleges. A selection of lectures by leading scientists lecture on diverse and advanced topics given at these camps have been edited and brought out to assist in Curriculum Development at the undergraduate level. Some of the project work carried out by students were published in international journals and some were even presented as invited talks in international conferences in India and Europe.

The Eighth Batch (Batch VIII) of NIUS Physics students had their first camp (VIII.1). 73 students from three streams - regular B.Sc, integrated M.Sc, and B.Tech/B. E - were invited to attend the first camp, out of which 67 students attended. Several lectures during this camp were devoted to astronomy and astrophysics. Seven students were assigned two-year projects in these areas under mentors at HBCSE and TIFR. In addition, six students from the Seventh

Batch of NIUS Physics continued their projects with respective mentors. Research in the area of asteroseismology was carried out at HBCSE with six NIUS students. Three past students completed their NIUS projects in the same area.

From this batch 45 students are currently pursuing NIUS projects. In addition 25 students from earlier batches of NIUS Physics also visited HBCSE to complete their projects and prepare manuscripts for publications and conferences. In December 2011 a one-day seminar was organised for NIUS Physics students in which eight students who have completed their projects presented their work.

NIUS faculty taught two courses at the Centre for Excellence in Basic Sciences. Identifying**,** encouraging and working with faculty in Non-Metropolitan colleges has been done in half a dozen places in India with a plan is to enable the teachers to set up a modest research effort so that they in turn will mentor the undergraduate students. The research areas are nanophysics (both theoretical and experimental) and quantum chaos.

The NIUS Chemistry camp was conducted with 39 students, of which 21 students were selected for project work. In addition, NIUS students selected from previous the batch visited HBCSE to complete their projects and prepare manuscripts for publications and conferences.

The NIUS Biology camps was conducted with 29 students, of which 9 students were selected to pursue project work. In addition, 3 students from earlier batches of NIUS Biology also visited HBCSE to complete the projects and prepare manuscripts for publications and conferences**.**

IV. Teacher Orientation and Science Popularization

Teacher Education has been an area of research and practical interest at HBCSE. The Ministry of Human Resource Development (MHRD) with focus on teacher education institutes in the Eastern and North Eastern States requested HBCSE to present a proposal in science and maths education for the States of Bihar and West Bengal. The program will involve about 100 teacher educators / teachers in Bihar and West Bengal. In February-March 2012 about 10 members of HBCSE visited several DIETs (Bikram, Muzaffarpur, Vaishali, Gaya, Nalanda, Barh and Ara in Bihar, and Howrah, Nadia, Burdwan, Murshidabad and 24 Parganas North and South), to assess the ground reality. The visits were followed by two-day workshops in Patna and Hoogly for faculty from all the DIETs, focusing on science and mathematics teaching at the elementary level. Based on an analysis of these experiences the interactions over the next year are being planned.

One of the ongoing work at the *Gnowledge Lab* has been to conduct workshops and orientation programs on digital learning studios. During this year, apart from conducting workshops within the campus and in Mumbai, programs based on the specially customized GNU/Linux distribution containing several platforms for learning science and mathematics were conducted at other cities: Bangalore, Goa, Pune, Kolkata, Burdhwan and Delhi.

On the request of the Sarva Shiksha Abhiyan unit of the Madhya Pradesh, an orientation workshop was conducted in Bhopal on "how to write research papers" for teacher educators, who were DIET faculty of Madhya Pradesh. Training courses were conducted for the practising teachers in science and mathematics at Nashik (Maharashtra State), and Khorda village (Gujarat).

HBCSE staff are resource persons in the Karnataka Government and IISc sponsored monthly teacher training programmes for high-school and pre-university teachers at a new IISc campus at Kudapura, Challakere Taluk, Chitradurga district, Karnataka.

HBCSE staff participated in the the 3-day teacher training programme for chemistry teachers of Allahabad organised by Vigyan Prasar and sponsored by DST to mark the International Year of Chemistry (IYC-2011), and was involved in developing the chemistry experiments.

In collaboration with Atomic Energy Education Society, HBCSE conducted for the 14th year the community development programme at 10 centres around the country. Students, teachers and teacher educators continued to visit the Centre. About 20 such visits were organized this year, besides the organisation of the Open Day on the occasion of National Science Day, in which more than 1000 students participated.

"Day Time Astronomy: Transit of Venus 2012" workshop, organised by Vigyan Prasar, HBCSE, All India People's Science Network (AIPSN) and Nava Nirmiti and held at HBCSE, Mumbai, 1st and 2nd March 2012. The workshop was a master resource persons' training workshop for day-time astronomy activities. A total of about 50 teacher trainers from 17 Indian states participated in the workshop.

V. Conferences and Workshops

National Initiative in Mathematics Education (NIME): Under the NIME initiative five regional conferences on mathematics education have been held across the country in November and December 2011. The series of conferences concluded with the National Conference at the Homi Bhabha Centre for Science Education in Mumbai in January, 2012.

NIUS astronomy winter school: Like every year, past astronomy olympiad students were invited to participate in a 2 week winter school from 5th to 16th December 2011. This year's school held at HBCSE, Mumbai was attended by 20 students. The students participated in various projects like study of Herbig Ae-Be stars, study of x-ray binaries, solar MHD simulations and open cluster observations using 2mt IGO telescope.

Developing science teaching methods for addressing diversity in classrooms: Two teacher workshops funded by Australia India Council, organised by HBCSE jointly with resource persons from Curtin University, Australia was held during 9 to 14 January 2012.

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