A Study of Policies Related to Science Education for Diversity in India[1]

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Abstract
This paper presents the findings of a study concerning educational policies related to science education and diversity in India which is a geographically and socio-politically diverse country. If the education system does not completely ignore the issue of diversity, two manifestations are possible: diversity poses challenges to curricular and classroom transactions, or is viewed as an issue to be addressed by curricula for cultural preservation or national integration. A study funded by the European Commission FP7 program between 6 partner countries, the United Kingdom, the Netherlands, Turkey, Malaysia, Lebanon and India aims to understand the complex overlapping relationships that exist between cultural and socio-economic diversity, gender and science education. In the Indian context attempts were made to understand existing educational policies and curriculum development structures and on identifying approaches and barriers to supporting diversity in science education. Literature shows that there is no decline in interest among students wishing to pursue science. The government is promoting science education by introducing schemes, fellowship programs, encouraging use of ICT, and advocating science events, yet, rarely addressing the issue of diversity. This paper highlights the main trends pertaining to science education for diversity in India.

Key words: Science education, diversity indicators, educational policy, education for diversity

1. Introduction

Knowledge of science and scientific ways of thinking is essential to participation in democratic decision making when issues concerning science are involved. Understanding the complex relationship between cultural diversity, gender and science education is important as it may affect the students' choice of taking up an education in science. The problem is already felt in some European countries as a dearth of qualified persons with a science, technology engineering and mathematics background (van Langen & Dekkers, 2005).

A project titled *'Science Education and Diversity*' (SED) was initiated by the University of Exeter and involves the six partner countries, namely the UK, the Netherlands, Turkey, Lebanon, India and Malaysia. The project funded by the European Union's FP7 programme aims to design new approaches to science education that will appeal to all students and are sensitive to diversity in a global context. The three year project began in January 2010 and is expected to complete in December 2012.

The project has been divided into six Work Packages. This paper deals with Work Package2, which was lead by the Indian team from the Homi Bhabha Centre for Science Education, Mumbai. The study aimed to understand how the current educational policies are addressing the diversity that exists in each of the partner countries. It highlights the barriers

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that hinder the development of policies that support education for diversity and their implementation. Factors facilitating the reform process were important for the study so as to be able to provide guidelines and programmes for effective interventions to improve science teaching wherever necessary. Each partner country submitted its country report to the Indian team and on the basis of these country reports a synthesis report was written (Choksi, *et. al*., 2011). This paper is based on the India Country Report (Choksi, Chunawala, & Natarajan, 2010), which includes a critical review of literature from multiple sources. The paper will discuss the existing diversities in India, the structure of education in the country, the various educational policies addressing diversity, the agencies responsible for curriculum development, the national curriculum framework. It will also present a typical Indian science classroom along with Indian students' attitudes to science education, and finally government efforts at science advocacy.

2. Diversity in India

India is the second most populous country in the world with around 1.2 billion people, that constitute about 17／ of the world's population. It is geographically and politically divided into 28 states and 7 union territories (UTs), and within these divisions exist several more sub-divisions in terms of caste, regions, languages, religions, socio-economic classes, habitation and gender. The Indian society is stratified on socio-economic lines on the basis of castes. Membership in a caste is based on birth and there are literally thousands of castes and sub-castes in India. Historically castes involve occupational specialisation and are interdependent with there being some correlation between caste hierarchy and economic prosperity. Some indigenous tribes have also become integrated into the caste system (Heitzman & Worden, 1995). In the rural areas caste and class tend to intersect and hence the Government of India introduced the term "Backward Classes" for castes which are both economically and socially disadvantaged. In 1950, a complete listing of castes and tribes was made and these included those groups that had been termed Scheduled Castes (SCs) and Scheduled Tribes (STs) by the British. According to the 2001 Census, the SCs are about 16／ and STs about 8／ of India's population. The number of tribes in India is over 700 and these reside in about 15／ of the country's habitats (GOI, 2001). According to the Multi-dimensional Poverty Index (MPI), which includes ten indicators such as, education, health and standard of living, about 55／ of India's population is poor. A large percent of the Scheduled Tribes (about 81／) are poor according to this index. The Scheduled Castes (about 66／) are the next largest group suffering from multi-dimensional poverty followed by the Other Backward Classes (about 58／). In the general population about 33／ come under this form of poverty (Shrinivasan, 2010). India is linguistically diverse, there being 22 official languages and over 100 non-scheduled languages as listed in the Constitution. Hindi is the official language of the country is Hindi. Four of the world's religions have originated in India, namely Hinduism, Jainism, Buddhism, and Sikhism. Islam and Christianity are two of the other major religions followed widely in India. Zoroastrianism and Judaism have existed in India since ancient times and have a few thousand followers. India is a secular republic and freedom of religion is a fundamental right. Hinduism is practised by the majority of the people (80.5／), followed by Islam (13／), Christianity (2／) and Sikhism (2／) according to the Census of India, 2001.

According to the 2001 Census, the sex ratio in India is 933, that is there are only 933 females per thousand males. The ratio is better in the rural areas (946) and worse (900) in urban areas (GOI, 2001). The provisional report of the 2011 Census reports that the national child sex-ratio has dropped to 914, which is an all time low since Independence in 1947. In India,

poverty, social inequalities and gender relations intersect in different ways in different regions (Ramachandran, 2009) and hence gender needs to be viewed within the larger social and regional context. The heterogeneity and diversities in India pose a challenge to educational development which is trying to address an immensely large population with complex identities and relations.

3. Educational Policies Addressing Diversity

Formal education in India is a hierarchically structured system from kindergarten to university, including institutions of technical and professional education and training. It requires that up to a given level, all students, irrespective of caste, creed, location or sex, have access to education of a comparable quality. While the national system of education aims at a common educational structure, constitutional provisions, educational policies and programmatic interventions have strived to address challenges posed by diversities that characterise the country and its people. Most matters related to school education, including curriculum, were under the jurisdiction of the State governments until 1976 and the role of the Centre was restricted to providing guidelines on policy issues. In 1976, the Constitution was amended to include education in the Concurrent List, whereby power is vested in the State and the Centre for legislative subjects contained in it.

After Independence, the concerns of education articulated during the freedom struggle were revisited by the National Commissions, the Secondary Education Commission (GOI, 1952-53) and the Education Commission (GOI, 1964-66). National Policy on Education (NPE) 1968 came into being followed by a comprehensive review of education in the country carried out by the Education Commission and the recommendations it made.

The principles of NPE 1968 aimed to promote national progress, a sense of common citizenship and culture and to strengthen national integration. It laid stress on the need for a radical reconstruction of the education system to improve its quality at all stages and correct regional imbalances in the provision of educational facilities. In addition to this, principles enunciated by the policy included emphasis on education of girls to achieve social justice and accelerate social transformation; intensified efforts to develop education among the backward classes and especially among the tribal people; promotion of educational interests of minorities; and development of integrated programmes to enable physically and mentally disabled children to study in regular schools. In response to the diversity of linguistic situations in the country, the three-language formula was adopted. The NPE prioritised science and technology, and wanted science and mathematics to be integral components of education till the end of schooling (GOI, 1968).

NPE 1986 emphasised education to be bring about equality for women. It prioritised elimination of female illiteracy and the obstacles that hindered girls' access to education. The policy focussed on retaining girls students until completion of elementary education and on women's participation in vocational, technical and professional education at different levels (GOI, 1986). NPE 1986 also furthered the cause of education of the Scheduled Castes and suggested that efforts be made (such as recruitment of scheduled caste teachers) to bring these students on par with the non-SC students. To improve the education of the Scheduled Tribes, the policy recommended that primary schools be established and residential schools be set-up in tribal areas. It suggested that the curricula emphasise the rich cultural tribal identity of students and that instruction be provided initially in tribal

languages and introduce regional languages in later stages. NPE 1986 paid attention to protecting the languages and culture of minority groups and highlighted the need to implement Constitutional guarantees that are given to these groups to establish and administer their own educational institutions (such as *madrassas* and *maktabs* which are religious institutions that impart general education to the Muslim minority population).
The Central Advisory Board of Education (CABE) introduced in 1992 modified NPE 1986. It widened access to secondary education and emphasised enrolment of girls, SCs and STs, particularly in science and vocational streams. Computer literacy in secondary schools and equipping children with technological skills were key concerns. It proposed a national framework for curriculum to help in the evolution of a system of education that would address India's diversity while maintaining a common core of values along with academic components (GOI, 1992).

4. Structure and Practice of the Education System

In accordance with the National Policy on Education 1968 and of 1986, school education consists of 12 years (Figure 1). This is also viewed as providing eight years of elementary education, two years each of secondary and higher secondary education and three years of university education (8+2+2+3). There is high degree of uniformity in the pattern of educational structure within a particular State or UT and also a broad consensus has emerged for adoption by all States (GOI, 2000).

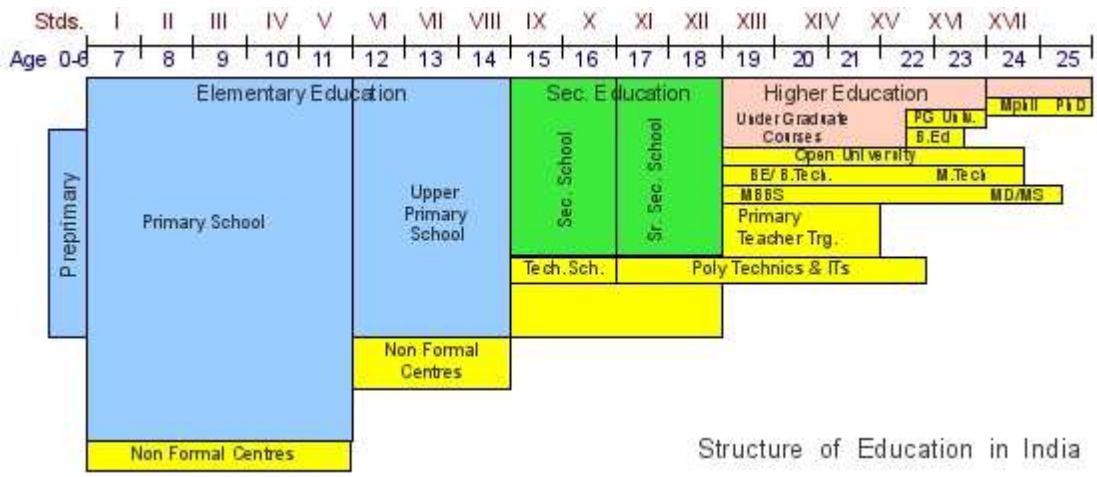

Figure.1: Stages of school education in India

Source: Development of Education: 1986-1988. National Report of India

In 2010, The Right of Children to Free and Compulsory Education Act 2009 came into effect. This act tries to meet the constitutional obligation of providing free and compulsory education to all children up to the age of 14. According to this Act, every child in the age group of 6-14 years has the right to free and compulsory admission, attendance and completion of 8 years of elementary education. The Act makes it mandatory for schools to promote all students up to Class VIII.

Elementary education is directed at developing literacy and numeracy skills and tries to acquaint the child with his/her social and physical environment, facilitate creative

expression, and healthy living. Secondary education is aimed at developing the intellectual, social, and moral qualities required for democratic citizenship. It is intended to prepare the young for entry into the world of work or for continuation of academic goals (GOI, 1952; GOI, 1964-66). These efforts have had results. Gross enrolment ratios (GER) have increased significantly across all social categories, drop out rates at primary level have declined, and transition from primary to upper primary stage has improved. At primary levels, the proportion of SC and ST enrolment with respect to total enrolment is around 20／ and 12／ respectively. At elementary levels, the share of OBC is 42／ and the share of Muslim enrolment is around 10.5／, (NUEPA, 2010). The Gender Parity Index (GPI) shows improvement in the percentage of girls' enrolment in primary and upper primary. At elementary level of education, enrolment of SC, ST, OBC and Muslim girls is similar, at 48／. Yet a large section of children who are still outside the general education system are children with disabilities. The Integrated Education for the Disabled Children (IEDC), is operational in over 90,000 schools benefiting over 200 thousand children with disabilities, but still large numbers are left outside the education system.

State policy with reference to bilingual education has been introduced in some states, where one language is used as a partial medium, along with English, Hindi, or the neighbouring regional language as the major medium. Bilingual education has been introduced for tribal communities and also minority communities. Vocational courses are introduced at the higher secondary education level to support the diversification of educational and employability opportunities. Since 1988, a centrally sponsored scheme of vocationalization of secondary education at the +2 level is in place. The scheme is aimed at providing a variety of educational opportunities to increase employability, and reduce the gap between demand and supply of a skilled workforce and provide alternatives to those who wish to pursue higher education. Vocational education is under the Ministry of Human Resource Development (MHRD) and the All India Council for Vocational Education.

In its size and diversity, India has the third largest higher education system in the world, next only to China and the United States. Higher education in India covers all post-secondary education beyond Class (Std.) XII in different subject areas, including all professional streams such as engineering and technology, medical, agriculture, etc. It comprises three levels of qualifications Bachelor’s or under-graduate degree programmes, Master’s or post-graduate degree programmes and the pre-doctoral and doctoral programmes. Although playing a critical role in knowledge generation and promoting India’s integration with the global knowledge economy and society, the enrolment rates at higher education at 11／ are relatively small (The World Bank Report, 2009).
Technical Education has a vital role to play in human resource development of the country by creating skilled manpower, enhancing industrial productivity and improving the quality of life. There are 65 centrally funded institutions for technology and science education such as the Indian Institutes of Technology (IITs) focussing on engineering education and research, Indian Institutes of Information Technology (IIITs), National Institutes of Technology (NITs) which focus on under-graduate education and training in different branches of engineering & technology, Indian Institute of Science (IISc), engaged in higher learning and advanced research in the fields of science and engineering, and Indian Institutes of Science Education and Research (IISER) broadly on the lines of IISc. The latter are devoted to under-graduate and post-graduate teaching in sciences in an intellectually vibrant atmosphere of research

and make education and career in basic sciences more attractive by providing opportunities in integrative teaching and learning of sciences.

5. Agencies Responsible for Curriculum Development

The MHRD which has the development of human resources as the overall objective looks after the Departments of School (Elementary and Secondary) Education and Higher Education. The main reason for having these departments as a part of the MHRD is to ensure that education does not operate in isolation but functions as an integral part of the entire system. The responsibility of administering and financing higher education remain with the State governments but are operated through universities and other autonomous institutions which work according to the guidelines laid by the University Grants Commission. School education is looked after by local self-government bodies along with State agencies (NIEPA, 1988).

The National Council of Educational Research and Training (NCERT) assists and advise the MHRD and also prepares and reviews school curriculum. The State Councils of Educational Research and Training (SCERTs) aid State governments in formulating and implementing policies, programmes and innovations in school and teacher education. The Central Board of Secondary Education (CBSE) prescribes courses and syllabi, organises orientation programmes and undertakes development and publication of textbooks, for secondary and higher secondary education levels.

6. National Curriculum Framework

For the sake of uniformity of standards and for national identity, the NCERT in 1975, developed a framework for a common curriculum (The Curriculum for the Ten Year School: A Framework, NCERT, 1975). Curriculum was defined as the sum total of all the deliberately planned set of educational experiences provided to the child by the school. However, the implementation of this curriculum was uneven and there was a mismatch between the curriculum objectives and the actual transaction in the classroom. This resulted in disparities in the standards of education achieved by students of schools in different parts of the country.

The NCERT in 1988 brought out a National Curriculum for Elementary and Secondary Education: A Framework, (NCERT, 1988) focussing on providing equal educational opportunities to all, not only in terms of access to educational facilities, but also in the conditions for success; a 10+2+3 structure of education; and minimum levels of learning norms for each stage of education. A discussion document on National Curriculum Framework for School Education (2000) was released by NCERT. The new curriculum framework sparked off a fierce debate for its introduction of a spiritual quotient, education about religions, value based education, teaching of Sanskrit, and emphasis on the 'traditional' social order and its values.

The National Curriculum Framework 2005 at present is the operational guide of school education. It reflects the collective socio-political aspirations of the whole society and has a significant pedagogical purpose of directing teachers to choose the content and methods of education. According to the NCF 2005, the curriculum, is a conceptual structure for decision

making as opposed to a layout of what is to be done in the classroom. It not only organises different elements of education but also makes connections between them.

Some of the main recommendations of the NCERT 1975 document have had a direct bearing on the teaching of science, its syllabi and textbooks. According to NCF 2005, at the primary stage the child should be engaged in joyfully exploring the world around it. The objectives at this stage are to nurture the curiosity of the child about natural environments, artefacts and people, to have the child engage in exploratory and hands-on activities, to acquire basic cognitive and psycho-motor skills; to emphasise design and fabrication, estimation and measurement as a prelude to development of technological and quantitative skills of later stages; and to develop the basic language skills: speaking, reading and writing not only for science but also through science. Science and social science should be integrated as Environmental Studies (NCF, 2005).

The NCF recommends the pedagogical use of activities and experiments at the primary levels as the main method for students to acquire scientific concepts, such as, group activities, discussions with peers and teachers, surveys, organisation of data and their display through exhibitions, etc. in schools and neighbourhood. At the secondary stage experimentation is an important tool to discover and verify theoretical principles. This stage would involve working on locally significant projects in science and technology. Science is introduced as separate disciplines of physics, chemistry, biology at the higher secondary stage. At this stage emphasis is laid on experiments, project-based learning, history of science to understand key concepts of science. In practice however the situation is very different as depicted in the box below.

Vignettes From Indian Science Classrooms...

A teacher stands in front of the class addressing students who listen in silence, obediently, and speak only when asked to; a student stands up and reads from the textbook while the entire class is silent; a teacher demonstrates an experiment as students watch eagerly...

A “typical” Indian classroom is difficult to describe given the diversity in terms of location (urban/ rural), funding body (government/ aided/ private) and therefore availability of resources. A large majority of students go to rural schools where even basic infrastructure like classrooms, seats and desks, toilets are lacking. These schools grapple with problems pertaining to attendance (students and teachers both) and basic literacy and therefore the time and effort they put into “science education” may be limited. The classrooms we describe here are more representative of those with at least the basic amenities.

The most prevalent form of teaching across Indian classrooms is the traditional (direct instructional), teacher-centred approach with the classroom discourse mostly in the form of lectures (by teachers) and whole class “discussions” with students' contributions coming in the form of single word or phrase responses, mostly in chorus.

The textbook and the blackboard are the main resources used. The textbook is followed strictly, along with the sequence of chapters and the sequence within the chapters. The questions given at the end of the chapters figure in the examinations. In “covering” each chapter, 2-3 class periods are used to explain the chapter, which could include some activities and experiments given in the text; then the chapter is read aloud by the

teacher or one of the students and this is followed by a note-taking session, when students write down answers to the questions given at the end of the chapter.
Activities and experiments are mostly demonstrations by the teacher. Participation of students mostly happens in the form of contributing material, answering questions, observing and occasionally one or two students assisting the teacher for some procedure; there is little scope for discussion and group work with peers. Students at the middle school level are occasionally taken to the science laboratory for demonstrations. Students in Grades 9 and 10 have a "practical" component in the science course, where they can do some experiments themselves as prescribed in their laboratory manual.
(We acknowledge Aisha Kawalkar and Aswathy Raveendran for the above vignette)

7. Students' Attitudes Towards Science Education

The first India Science Report (Shukla, 2005) was commissioned by the Indian National Science Academy (INSA) to National Council of Applied Economic Research (NCAER). The results presented in this report were primarily based on information collected through an all India field survey called the "National Science Survey–2004" undertaken by NCAER and supplemented by information available from various reliable secondary sources. The report found that mathematics remains the most preferred subject, with a third of students in classes six to eight rating it as number one. Subjects like Physics, Chemistry, and Biology are rated as the top subjects in classes 11 and 12 by about 30⁄ of the students. This figure is triple that for students in classes six to eight suggesting that the attraction for science subjects increases dramatically in the higher classes in school.

At the class six to eight level, 22⁄ of the students said they would like to study pure science at higher levels of education. Yet, only around 13⁄ of the students in class 11 and 12 wanted to study pure science at the graduate/post-graduate level. The interest in all types of science education does not decline much - 60⁄ of the students at the class six to eight level said they wanted to pursue some science education (pure science, engineering or medicine) at a higher level as compared to 57⁄ students in classes 11 and 12.

Most students (close to two-thirds) in classes six to eight are satisfied with the quality of science teaching, this falls to 40⁄ in classes 11 and 12. About 60–70⁄ students are satisfied with the quality of teaching of most of the subjects. Overall not too many students (10⁄ at the +2 level) state that they keep away from science as it a costly subject to pursue. About 45⁄ state they are not pursuing science because they have no interest in science.

Parents and teachers play an important role in the selection of courses as well as in deciding career choices. Regarding career aspirations, over 40⁄ of the students, whether in classes six to eight or 11 and 12, wanted to become either an engineer or a doctor. The three most preferred professions for students turn out to be teacher, doctor and engineer.

A study conducted to understand middle school students views about science (Chunawala & Ladage, 1998) revealed the highly positive image of science and scientists held by Indian students. However, this positive image had stereotypical aspects. A positive image of science and scientists among Indian students may be viewed as favourable in a developing country like India and most students considered science as essential for the progress of the country.

However, the masculine image of science held by both boys and girls is an obstacle in the path of this progress. Appropriate inputs into the educational system may help in transforming these existing images of science.

8. Science Advocacy

Even though the studies presented above indicate that there is no decline in interest in the section of students who wish to pursue science, the government continues to promote science education through introduction of various beneficial schemes for schools and students and scholarship. A centrally sponsored scheme since 1987-88, has the aim of promoting scientific temper and improving the quality of science education in the States, by providing assistance for provision of science kits to upper primary schools, upgrading the laboratories and library facilities for secondary schools and training of science teachers.
A programme called '*Kishore Vaigyanik Protsahan Yojana*' (KVPY) (meaning Programme for Encouragement of Young Scientists) was initiated by the Department of Science and Technology (DST) to encourage under-graduate and graduate students of basic sciences, engineering and medicine to pursue research careers. Apart from these, learning enhancement and computer literacy programmes were started with the objective of strengthening science and maths learning at upper primary level and familiarizing school children with computers respectively. According to the flash statistics for elementary education in India report, it was seen that 14⁄ of schools have a computer, as of 30th September 2008 (NUEPA, 2010). A centrally sponsored scheme was launched in December 2004 to provide opportunities and build ICT skills among secondary students. This scheme provides support to the States to set up ICT infrastructure.

Another beneficial programme developed by the DST to attract young talent towards science is the INSPIRE scheme. According to the scheme, scholarships are awarded to a select percentage of bright students who wish to pursue science in their under-graduate years. Also, scholarships are made available for those under-graduate and graduate students who wish to pursue science. The scheme also provides doctoral fellowships in the age group 22-27 years, in both basic and applied sciences. A centrally sponsored *'Scheme for Providing Quality Education in Madrassas'* was launched in 2009 through the National Institute of Open Schooling to accomplish some qualitative change in the education being imparted in madrassas and maktabs to bring them up to the standard of the national education system.
In addition, the Jawaharlal Nehru National Science Exhibition, science museums, events of the National Children's Science Congress, National Science Day, etc. are all means and methods to inculcate and attract young minds to science. The current formal system of education, however, does not espouse the exploratory way of learning science (Indian National Science Academy, 2001).

9. Conclusion

Over the last few decades, India's population has been on the rise. Caste, class, religion, language, region and gender which are markers of identity create a complex diversity in the Indian society. The growth in economic prosperity parallels rising inequalities. The economic inequalities often go hand in hand with social inequalities sharpened by gender, caste and religious groupings. This situation poses a threat to educational development in the country.

The education system does at times ignore the issue of diversity. The uniform curriculum and the central development and dissemination of the textbooks does not focus on the diversity in the country. In fact, it views the students as a homogeneous mass and science as compulsory at the schooling stage. Surprisingly, science still remains an attractive career choice among the young minds.

Lack of basic resources, poor curriculum development, language barriers, gender issues and a wide rural-urban divide acts as major barriers when it comes to supporting diversity in education. Right from independence, deliberate efforts have been made in India, in terms of educational policy-making, which has paid greater attention to the general educational deprivation experienced by the girl child or children from minority ethnic/cultural identity groups. The various policies like NPE 1968 and 1986, NCF 2005 were all bought into force to address the diversity existing in India.

Immense efforts have been made by government and private agencies to acknowledge the existing diversity in science education, through various changes in curriculum development and innovative teaching education and training programs. The teacher recruitment procedures are also somewhat standardized, but the implementation and spread of schemes that involve teacher improvement programs has been irregular through the states. The government has been trying to promote science education through introduction of various beneficial schemes, fellowship programmes, encouraging use of ICT, and advocating science events. Even on the research front, apex institutions like Homi Bhabha Centre for Science Education (HBCSE) have been focussing on various issues pertaining to science education in India.

In the global context, science education is a concern because of the declining interest and dwindling numbers choosing science as careers. The SED project funded by the European Union's FP7 programme involving six partner countries, (the UK, the Netherlands, Turkey, Lebanon, India and Malaysia) aims to understand the mosaic of cultural, socio-economic relationships with science education and accordingly design new approaches to science education that will appeal to all students and are sensitive to diversity.

India led Work Package2 dealing with documentary analysis of educational policies and this work has provided the base for the later Work Packages. Work Package3 involved survey and case studies of students and teachers, which gave a broad understanding of students' and teachers' conceptions about science education. This in turn, has provided the necessary theoretical framework, which contributes to developing intervention and Design Based Research (DBR) strategies. These, we hope, will address the critical issues of diversity in education.

Such research leading to further exploration of the complex relationships that exist between science education and cultural and socio-economic diversity can definitely serve as a valuable basis for designing new, simple yet flexible and diverse approaches to school science education. The efforts however, need to be well studied and evaluated in a methodical manner in order to draw long term effective solutions to address the concern of educating the diverse population of India.

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