

## 42. Reviewing Science Education Reforms and Science Literacy for All

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**Abstract.** There is need for creating a universally scientific literate society through “Science Education for All”. What is needed in this regard is to popularize science and consumerize technology. The presentation gives a brief analysis of the definitions of scientific literacy in relation to language literacy, dimensions of scientific literacy in the contexts of sustainable development and understanding of science as a social enterprise. It examines the role of science, technology mathematics education into a human enterprise for creation and sharing knowledge and developmental capacities to design envisioned future technologies for the benefit of mankind for peaceful co-existence. World science declaration 2000+ is corner stone of policy frameworks for reforms for science, technology, mathematics education for all. Some suggestions for Common curriculum changes are diversification, International competitiveness and issues of ethics and public understanding of science and technology and expected education reforms for promotion of scientific literacy at every level. Recasting the science, technology, and mathematics education for more relevant to needs, aspiration and interest of society is essential for popularization and communication of science and technology.

**Keywords:** Science and technology, Scientific literacy, Science Education for All, Science, technology and mathematics, Science, Mathematics and technology education, RMSA, NCAER, ISCA, IMSS, INSA

### Introduction

The Importance of science and technology (S&T) in every aspect of our lives in progressive nation like India has been restated many a times in important S&T resolutions (1-3). As the world becomes increasingly more and more scientific and technological increasing one’s scientific literacy (SL) is very important. The future of mankind depends on the enhanced effectiveness of education for growth of scientific literacy and its application especially for making personal and collective political decisions that can sustain our economy and democracy. We need to create a universally scientific literate society through “Science Education for All” (SEFA) the guiding principle in this regard is “popularize science and consumerize technology.

The American Association for the Advancement of Science (4) defined scientific literacy as the ability to use scientific knowledge and ways of thinking for personal and social purposes. Attempts have been made to define scientific literacy in relation to language literacy by several educationists (5-8). Despite some differences, whether scientific literacy is not dependent or dependent upon any specific science content or process knowledge the dimensions of scientific literacy include the following.

- Science content: understanding facts, laws, concepts and theories
- Scientific inquiry: understanding of the scientific approach to inquiry
- The ability to define scientific study and to discriminate between science and non-science
- Equal importance of science content and science processes equally
- According to Project 2061 scientific literacy (9) has many facets. These include (i) familiarity with the natural world and respecting its unity; (ii) awareness about the important ways in which science, mathematics and technology Education (STME), depend upon one another; (iii) understanding some of the key concepts and principles of science; (iv) developing capacity to understand the scientific ways of thinking and its importance;
- (v) knowing that STME are human enterprises, and (vi) understanding the implications about their strengths and limitations. All most all, subsequent definitions (10-12) of scientific literacy have been weaved around these facets.

Third International Mathematics and Science Study (13) (TIMSS) defined few additional objectives in this regard, viz.:

- Education for universal science literacy will, in addition to enriching everyone's life, create a larger and more diverse pool of students who are able and motivated to pursue further education in scientific fields.
- The first priority of science education is basic science literacy for all students, including those in groups that have traditionally been poorly served by science education.
- For students to have the time needed to acquire the essential knowledge and skills of science literacy, the sheer

amount of material that today's science curriculum tries to cover must be significantly reduced.

- Effective education for science literacy requires that every student be frequently and actively involved in exploring nature in ways that resemble how scientists work.

### STME for Sustainable Development

The understanding science as a social enterprise (14-15) is necessary for sustainable development. The broad access to scientific information is key for the people to understand, participate and respond to the challenges that development poses to civilization. Understanding of issues such as environment, global warming and climate change, air quality, loss of biodiversity, evolution, implications of genetic research, human health, hazardous substances, population growth, world hunger, water resources, energy security, degeneration in agriculture and many other topics is essential, almost a requisite, for personal involvement in searching solutions for these issues. Thus education with science, technology and Mathematics (STM) base is crucial to sustainable development. It is challenge for science educators all over the world to converge STME into a human enterprise for creation and sharing knowledge and developmental capacities to design envisioned future technologies for the benefit of mankind.

### Science Literacy for All (SLFA)(16)

- World Declaration on Science 2000+: “The declaration on science and use of scientific knowledge is part of the right to education and right to information belonging to all people for human development and creating of endogenous scientific capacity”.
- There is need to improve, strengthen, diversify and restructure STME both formal and non-formal with the objectives for sustainable development.
- STME can contribute to peaceful co-existence. It should not be seen as an instrument of warfare. It can be used as knowledge for conflict resolution by including subjects such as energy, pollution, environment, health care, medicine and use of resources and application of bio-technology, nanotechnology and nuclear energy for peaceful purposes.
- The society and Government must take responsibility for the same because the STME’s spirit and scientific temper in society can contribute to respect for human rights and dignity of labor.

### Post Sputnik Science Education Reforms

The main emphasis of the above reforms (17) undertaken during 1900-1950 were teaching of science as structured discipline to limited students in what, why, How, types and content of courses. The focus was not SLFA. But in India Kothari commission report (18) stressed need to transform education as per the needs and aspirations of people and focused on education as key to national development and importance of science education in this regard. The Kothari commission report expounded “Science has added new dimension to education and its role in the life of the nation, but central to all this is the quality of education. If science is poorly taught and badly learnt, it is little more than burdening the mind with dead information and it could degenerate even into a new superstition. What we desperately need is improvement in standards of science education at all levels”.

Three major goals of STME identified were in the report viz:

- (a) Prepare excellent Scientists
- (b) Training of teachers in new frontiers of knowledge
- (c) Produce scientific literate society. It shifted emphasis from knowledge process to skills and attitude of mind and also interaction between worlds

of knowledge with the world of work.

However, few distinctive drawbacks of these gigantic efforts were noticed as a result teacher proofing of curriculum, over emphasis on computer assisted learning, loss of interest of students in science and mathematics, and domination of university and research scientists alienating initiatives of school teachers in classroom situations. The assessment and evaluation did not receive a proactive support of scientists dealing with the reforms also. However, it impacted the thinking of scientists and educators equally in third world countries and brought together scientists, educators and teachers at all levels on a common platform for new resurgence characterized by sharing of knowledge and experience for worldwide paradigm shifts in approach to STME

### Revival of STME at National Level

The State of STME is at center stage again at national level because of global concerns for sustainable development, economic growth, better quality of life and “science education for all”(SEFA).

The second reason is renewed importance of basic sciences as expressed in the statement of Nobel Laureate

Aaron Ciechanover at ISCA 2007. He made an appeal for global focus on basic sciences rather than application for the research being funded. "If you don't have basic science, there is no applied science". Similar sentiments were expressed by science fraternity participating in INSA Initiatives on improving science teaching viz.

- Science education seminar, INSA–May 2002(19)
- Science education INSA Workshop–Oct 2002
- INSA report on science education in universities and Inter Academy discussions on improving science teaching.
- The national curriculum framework 2005 has elaborated the goals of S&M curriculum for schools.
- The recent NCAER 2005, India Science report gave the picture of state of science education in India.

All these reports examined various conceptualities for improving STME in India including poor quality of education, lack of experimental facilities, absence of good quality teachers, need for attracting good talent and removal of inadequacies in curriculum.

A brief overview of the science curriculums, textbooks, and teaching continue to lack focus and to emphasize quantity over quality. The definition of literacy must expand to include not only reading and arithmetic, but also science, mathematics, and technology. The life-enhancing potential of science and technology cannot be realized unless everyone understands the nature of these subjects and acquires basic scientific habits of mind. Without a science- literate population, the outlook for a better world is not promising. The STM education is considered an important component of science education (SE) in schools from K-1-12 levels all over the world to promote SEFA in view of universalization of secondary education( 21 ) under Rastriya Madhyamik Siksha Abhiyan (RMSA)-2009(22-23 ).

### State of STM Education in Schools in India

The recent NCAER 2005, India Science report (24) gives the picture of state of science education in India.

Some of the facts in this regards are:

- It is well known that good talented students are not opting science courses. It is worldwide trend and India is no exception.
- After 10 + 2 students enroll for B.Sc. degree only if they fail to get admission to courses like engineering, medicine, and commerce. Only 25% of entrants in K-12 system complete science courses. 10% recipients of National Talent search scholarships opt for science courses. The Percentage of student joining science has declined from 31% to 23.3% since 1990.
- Studies are not enjoyable and cannot attract students and there is dearth of good teachers. And the cost of higher education in science is higher and non-affordable. The infrastructure and laboratory facilities are in adequate also
- absence of brand institutions and resources for up-dating of learning material, laboratories, teacher training, lifelong professional development of teachers and promotion of basic research in methodology of science teaching.
- Limited job opportunities offered by the courses in vogue in school education i.e. vocational chances are limited at terminal level school science education.

Changes are also needed to meet requirements of science teaching post 2000+ such as competency in digital literacy skills in using learning technologies, knowledge of problem solving tools, inventive thinking along with marketable and practical skills applicable in effective communication.

### Policy framework for STME

- The World science declaration 2000+ is corner stone of policy frameworks (20) for reforms in STME. These principles have guided the directions of developments in the field STM education in this decade.
- Science literacy for all—"no child is left" and the inquiry based and exploratory method for learning SE is used so that learner himself can construct the knowledge.
- STME can contribute to peaceful co-existence. It should not be seen as an instrument of warfare. It has to be all-inclusive to ensure gender equity, participation of all including marginalized groups, and impact of globalization, public understanding and its influence in daily life, concern for ethics, human rights and culture of peace.
- Teacher is the vehicle for desired reforms in SE. The institutionalized training (pre-service and in-service training) of teachers and their professional development must receive a central place in resource planning.
- Financial and resource inputs are necessary for developing an enabling environment for science learning.

Integration of IT and communication technology in curriculum transaction for effective learning and lifelong

learning.

### Objectives of Common curriculum changes

- It provides knowledge of concepts and related broader contexts of STM and presents a balanced view of contents and applications. It connects facts and understanding of the factual material which includes observation, inference and application of the subject. It should be helpful in inquiry-based learning and experimentation. The Curriculum changes to include history of scientific discoveries and role of STME in everyday life to make learning enjoyable also. Simultaneously it integrates with other curricular areas such as reading, writing, business and social studies.
- Laboratory experiments provide linkages between theory and practical, as well as, facts and applications. It reflects the interdisciplinary nature of STM. It is inclusive of hand-on inquiry-based activities or experiments aimed at problem solving in social contexts using examples.
- Develops appropriate science experience based on visits to industry, environment and agriculture, so that it develops a global perspective of STM for sustainable development and improved quality of life. Its digital age, so it must enhance competence of students in information comprehension, use of computers for simulation, use of multimedia tools, Internet sources for data collection and virtual learning.

### Diversification of STME(20-21)

- Undertake structural reforms to improve strengthen and diversify STME to integrate with culture, promote open and critical thinking and enhance people's ability to meet the challenge of knowledge society.
- Diversify STME for many fold objectives: (a) science literacy, (b) science for skilled work force and service providers, (c) cadre of excellent scientists, through child centered knowledge and inquiry based learning (d) spreading science education in rural areas and building bridges with traditional knowledge.

### STME for International Competitiveness and Ethics

- Since the science education is necessary for training of sufficient number of trained people to satisfy the scientific and technological needs of the global society, capacity building in science and scientific culture is of utmost importance.
- Ethics and human rights and necessity for culture of peace and tolerance, advancement of communication and information technology has brought human races much closer. There is need for developing understanding of globalization, sustainable development, and willingness to acquire knowledge, skills and attitude towards responsible citizenship.

### Public understanding of STME at every level

- To ensure the power bestowed on human being by science is used for benefit for all and not for few.
- In developing countries, under investment, lack of policies and constant follow up activities is most importantly causing shortage of qualified teachers, appropriate teaching material and adoption of new technology as serious handicaps. All efforts are made both at national and international level to make science education internationally competitive at every level. It is necessary for meeting the challenge of globalization and trade in services of education.
- Scientific temper is guaranteed against the forces of religious fundamentalism and obscurant and dead traditions.

### STME–More Relevant to Needs, Aspiration and Interest to Society

- STME for all round development (20) encompassing, intellectual, personal social and economic development as core subject at all levels to meet the needs of students for future citizenship, enabling them informed and appropriate choices about learning and career development.
- To enable students for adequate preparation for 21st century to meet present and future social needs. The changes made in the Curriculum on above counts and improvement of quality must be accompanied by concurrent changes in methods of delivery, teaching practices and learning resources.
- Inclusion of IT and computer applications as a core areas of study and sustainable development, concern for human rights, sharing of resources for quality of life for all social responsibility.
- Diversification of effective practices of STME for promotion of innovation and experimentation as part of learning support inter-alia formal and non- formal education.

- Outside class or laboratory learning through field visits, science museums, exhibitions, science projects presentation, quizzes, etc.
- Student Centered Learning and teaching in classroom and laboratory.
- Defining classroom and laboratory activities based on investigation of real life problems.
- Learning to be assessed based on how the learner uses the information and skill in constructing one's own knowledge based on investigations on relevance of STME to local environment. Development of life skills through STME is more important than only professional skills.

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