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Recalibrating Science & Technology Education for Environmental Sustainability- Re-Orientation of Text Books

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Abstract

Sustainability aims at keeping the future of civilisation and society alive. Science and Technology is a tool for this. India has a long tradition of science, education and now a vastly expanded technical education system. New Textbooks or Learning Materials-print or digital, are absolutely essential for this to fulfil particularly. SDG, as listed Globally or Nationally.

India's ranking comes low in PISA, which is an International Students' Evaluation for applying science education to real life problems, for school leaving students. Sustainability is linked to reality. In Global Institutional Ranking also India's ranking is not high for the Universities. One of reason is improper learning materials, leading to unsustainability mindset.

This paper attempts to find the reasons the shortcomings. From experience, observation and study, the author has attempted to point out solutions in one major area, i.e., paradigm shifts required for text books on Science and Technology, particularly at middle school level and Technical Institutions. One of the major conclusion is that, it is important to change orientations of Indian books with clarity and lucidity, the sustainability concepts. Writing books by Indian teachers mostly and involving learned professors in writing texts will enhance the technical knowledge base of the students, increase their employability by clearing fundamental concepts and thus take India forward to a sustainable future as a whole. This will also enable inclusive education and will also enhance the 'Make in India' conceptual framework.

Key words

Sustainable development, engineering education, text books in science, text books in engineering.

1. Introduction

Industrial Revolution is the broad term to denote the dawn of modern Industrial Civilisation. Historically the time is around 1780, when James Watt in U.K. modified the Steam Engine, burning coal, based on the discoveries by Thomas Savery (1698) and Danins Papin (1712). This, together with colonial expansions brought unbridled economic prosperity to the world. Developments in Science and Technology also proceeded very fast. Economic Growth was concurrent. But very few thought that this will usher in a crisis to sustainability-crunch for natural resources and a damaged Eco-system. The concept of sustaining finite resources for future generation was formally coined in the 1987 'Brundtland Report'. The relationship between Technology and Nature started to be questioned. However it was in the 1972 'Club of Rome Report (Limits to Growth), a simulation was done with five variables, of which industrialisation, pollution and resource depletion were three. Three future scenarios were predicted, of which two predicted 'Overshoot & Collapse' of the world system and that too, by mid 21st Century! It may be considered the first report on sustainability. Now that climate change, Global Warming above 1.5^{0}C from pre-industrial area and such effects are studied, all are aware of the catastrophe caused by uncontrolled development. Doubts arise-do advanced technologies make future life more happy and secure or are humans being exposed to greater dangers?

A major role is played in the world of today by Scientists and Engineers. The paper aims to discuss some of the paradigm shifts necessary in science education at school and technical or engineering education at Institute/University level, so that some of the sustainability goals are fulfilled and imbibed in the minds of future citizens. The paper conceptualise that only a bottom up approach can satisfy most of the SDG, inclusive education being one of them.

2. Science Education in Indian Schools

2.1 Present Status

For objectivity this paper as has taken the test PISA, Programme for International Student Assessment, conducted by the OECD and allied countries. It conducts school level tests for Reading, Mathematics and Science. Scores are given for all three categories. About 73 countries

took the 2012 test. 2 states of India were almost at the bottom of 73 participants. Finally, India pulled out of the PISA test that year. The 2015 examination results will be out in December, 2016.

The results are bad for Indian students. Multiplicity of examination conducting boards and languages of different states may be two major problems. But this does not address SDG.

2.2 The Sustainability Way-out for School Education

The National Curriculum Frame Work-2005 (NCF) as framed by the MHRD, Govt. of India includes two major points which is still not being properly implemented :

(i) Connecting knowledge to life outside the school;

(ii) Enriching the curriculum so that it goes beyond text books.

As sustainability needs connecting with nature, these two are very important. It is felt that for inclusive, sustainable education (SDG4) following are to be done immediately :

- Less books, more contact with real life [please refer to 'Learning without Burden', 1993, MHRD].
- Leaves of Trees, Composition of Clay, Sands, Rivers should not be taught from book only. Visits, excursions, practicals are essential.
- Animals and Fishes can be shown in zoos and markets respectively, supplementing knowledge from books.
- Texts, even to teach literature, used to set examples from real lives. We all remember the line 'bullock driven carts of claymodellers locality' from the 'Sahajpath' written by Rabindranath Tagore used as a primer of vernacular in our schooldays.
- Tagore even gave the example of teaching history with time as x-axis and events/eras as y-axis so that, instead of a linguistic description of events, history would come alive with graphical images.

That his why, Rabindranath established first his Brahmacharyashram, followed by VisvaBharati in 1920s. His model was-classroom amongst nature. The trees, the birds were to inspire and integrate with education. Somehow, disconnect with nature occurred and the model is no longer working.

The role of informal education, intuition plays a major role; the science museums, science cities are playing and will play a major catalytic role here. The networking of Bombay IIT with the Nehru Science Center is a successful case, to be studied in depth. Here practical knowledge is acquired leading to sustainability approach. Children learn to 'leave together'.

3. Engineering Education, Sustainability and Role of Text Books

3.1 The Genesis

Engineering Education in India, started in early 19th century, namely in Guindy (then Madras), Bombay (VJIT), Roorkee (Thomas on College) and Pune. The courses were designed to train mainly supervisors to build roads, railways, bridges etc. to make colonisation smooth for Britishers. In Bengal also, the erstwhile B.E College, Shibpore started its campus in the then Presidency College.

But spirit of nationalism was awakening and basically two independent models developed: One was the Swadeshi model developed mainly by Satish Chandra Mukherjee with Raja S. C Mullick and Arobinda Ghosh in 1906, named the National Council of Education. Historically, this was the genesis of now Jadavpur University via National College and Bengal Institute of Technology. The idea was to prepare the countrymen for Industrialisation by self sufficient manufacturing technologies. Another model was for Research, as established by J.N.Tata, the IISC. IISC remained a PG and Research Institute.

In the curriculum of the NCE lineage, weightage was given on history and literature, which continued even when Jadavpur University was formed in 1956. Most of the alumnii agree that it helped to build a modern India where Jadavpurians played a main role.

Vast expansion of the Engineering education took place, post 1980 (after formation of AICTE).

3.2 Present Status of Engineering Education

India produces presently about 15 lakhs of engineers annually from 3345 colleges (2014-15). The question is, do they know about the sustainability approach. The answer will be-No. It has not been integrated into the curriculum. A paper on 'Environment' is not enough to teach sustainable growth models or sustainability transition either in Energy System, Manufacturing System, Electrical System etc.

Wherefrom students will learn? The print or digital texts studied are still mostly by foreign authors. So, Complex engineering problems, closed or open ended does not relate to our local conditions or phenomena, nor to SDGs. Yet it is one of the main criteria of Graduate Attributes to be attained as per Washington Accord of which India is now a provisional member. Students study foreign books in IITs and good universities (because they are of good quality) and on the other extreme there are the guide books/note books studied in majority of self financed colleges (which was unthinkable for engineering education even 20 years back!). The disconnect with Industries play a major role also. Definitely, digital libraries and resources have increased. But

educationists still agree that the best teaching-learning process happens in a classroom, and text books are a must read. But Industrialists have to help framing curriculum.

3.3 An Example of misinformation in Engineering Education: Refrigeration & Air-conditioning

One of the most successful global treaties, the 'Montreal Protocol' relating to the refrigerants (to prevent the menace of Ozone holes) was signed and implemented between 1987-1989. The Refrigerant - 12 or F-12 [tetrafluroethane) as it is called was banned. And in 25 years the Ozone hole over the Antartic is almost repaired and is set to reach the 1980 stage by 2050-2070. New refrigerants was used, innovations were rapid, and R-12 replaced quickly.

But most of the Indian Engineering Textbooks still contain problems with R-12, and they are taught. Many teachers are also unaware that R 134a, as used now, is on its way out with the implementation of the Kigali Agreement (September, 2016) to phase out HFCs which causes globale warming. So text books will have to be rewritten again and immediatey. Tables and charts of new Refrigerants to be incorporated.

In Refrigeration & Airconditioning books the thrust for natural refrigerants (CO_2 etc) for sustainability has to be incorporated. Research papers should transit to texts very rapidly for SDGs to be satisfied.

3.4 Climate Change and Energy Use

Global warming and climate change have been identified as two major sources of social un-sustainability; The Kyto Protocol, signed on 1996, was implemented in 2005 only. Thus reduction of Green House Gases was halted. Now, there is the Paris Agreement, signed on December, 2015 and effective from November, 2016 having two major objectives.

(i) To keep the global mean temp rise upto 1.5^0C above pre-industrial level at most.

(ii) Making finance flows consistent with a pathway towards low GHG emission.

The reason for Global warming has been mainly due to fossil fuel burning since Industrial revolution as conjectured by IPCC.

In the books now, the knowledge of renewable sources of energy are to be taught. Emphasis has to be given to conversion of energy to electrical and mechanical forms. More emphasis to be given to carbon dioxide production mitigation, assuming the industrail revolution era to be the baseline.

This needs a shift in engineering books from coal based Power Plants to renewable sources. Smart & dynamic grids have also to be part of education in Electrical Engineering. Low

temperature Heat Transfer need to be included. Electronics is a must for all the branches for use of the non-mechanical, less power consuming control systems.

3.5 Integration of Humanities & History Education with Technology

It was C.P. Snow, who is in 1959 advocated that the barrier between humanities and science be broken. The book 'The Great Derangement' by Amitava Ghosh pin pointedly says that, there should have been more discussion about effects of climate change like Deforestation, Destruction of Biodiversity etc. in Literature, Poetry & songs. Then more people could know about the imminent hazards of anthropogenic climate change. And more natural artifacts integrated with nature could have been built.

Conclusions

While discussing changes in Text books for sustainability concept inclusion, the following pathway can be outlined :

- In an age of Molecular Machines, Chemistry & Physics to be given more weight age in Engineering. Particularly to understand nano effects.
- Engineers should not 'neglect the negligible' Small has become important & beautiful. Micromaching is one example which is yet to become text book material.
- The barriers between disciplines in Engineering as they exist now should be changed. Interdisciplinaity should take priority as early as possible. Energy, Environment are such subjects.
- Text Books should be revised frequently & written jointly with practitioners. The role of publishing houses become very important here.
- History & Philosophy of Science & Technology should be brought, to induce in the mind, the question 'why', rather than 'how' ? This helps to reach out to problems of nature, which a technical person has to solve.
- The last but most important, eminent Indian Professors should write text books. That will provide lucidity and include nationally relevant technical problems. They have to substitute the foreign books as well as guide books here we can cite the example of M.N. Saha's book "Treatise on Heat", written in 1930s.

True, the world a Global village now. But the time has come to use technology in a humane way. Remembering the dictum, `Think Global, Act Local' needs to be memorized.

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