13. TOWARDS THE DESIGN OF AN ENGINEERING EDUCATION CURRICULA

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1. Introduction:

Engineering / Technical Education is the basic foundation of technology development and social change. The impact of technology on economy and society, is clearly visible, to all of us as global citizens. Many argue that the impact of the new emerging technology, as the Third Revolution Wave, is far more effective than the Agricultural Revolution or even the Industrial Revolution of the twentieth century. Advancements in the fields like; factory of the future, micro-electronics, information and communication technology, bio-technology, space technology, technologies of non-traditional energy sources, self-operating and lean and agile manufacturing technologies, green environment and industrial ecology etc. characterize the third revolution. These technologies are now also forming the important base for curricula development of technical education in India.

Technology has been responsible for major advances that touch on all aspects of our life. In this respect, technology has proven to be the major driver of social changes. Interaction between technologies and societies are desirable and sometimes, crucial. Hence, technical education must be related to social needs and must be guided by social ethics and morals. This indicates that engineering curricula have to be societies' specific. Apart from this important issue, let me highlight some more relevant issues such as;

- Does technology, sometimes, conflict with issues in ethical and spiritual values of Indian societies?
- Do we need to protect and preserve tangible and intangible cultural heritage and empirical knowledge from being lost or perverted by certain technologies?
- How technology could be tailored and guided to meeting social needs rather than meeting, innovators goals, whether political or economical?

These key issues will continue to be subjects for debate at all times. Technical educationists have to carefully delve in these matters. Some policy makers in India, suggest that although curriculum development are technically useful, they often overlook the human aspect such as the personal attitudes, feelings, values involved in curriculum making. Accepting that student motivation is an essential element in learning, I propose that those who teach, should begin to reclaim learning outcomes and begin to frame them more broadly and flexibly, by incorporating macro issues that impact a nation, to allow for demonstrations and expressions of appreciation, enjoyment and even pleasure. In the next sections, I intend to discuss very briefly some issues that need to be considered while developing a process oriented engineering education curriculum.

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2. The social system and the technology:

Technology is the result of the activities of social systems. A social system is composed of a number of elements, actors, or players who interact together. The main players in typical social systems are; the state, the civic society, the financial institutions, education and training institutions, the manufacturing enterprises, services sectors, and the research and development organizations. The Governments formulates plans and design policies. The civic society contains the bodies that supports/ impedes the policies and implement them for social development plans that are adopted by the State. In doing so, they set priorities in funding, according to the expected socio-economic impacts of the technology under consideration. Education and Training Institutions are concerned with the development of human resources; while Production and Services Sector utilizes the technology in producing goods or supplying services. The Research and Development organizations (including universities) exploit, develop, and design technology. The society, at large, is finally the consumer of the technology or its product.

3. Technology and the development of Societies:

It is universally recognized that technology plays a decisive role in every sector of development. This includes health services, food production, education system, energy conversion, communication, and transportation. Several studies in the past have argued that technology is used to empower people, allowing them to harness technology to expand the choices, in their daily lives. Moreover, technology itself has become a source of economic growth. Societies vary in the degree of interaction with technology and/or the extent they are affected by it. However, it is obvious that industrial societies are more affected by technical changes. This leads to more development and widening the knowledge base of these societies and intensify the atmosphere of knowledge usage. The result is more wealth to the industrial societies. Since the superiority of countries' wealth is a base for further development, a vicious circle is being composed. Such a self-fueled process widens the gap between the societies in industrialized and developing countries.

Noticing that, in contrast to the above, developing countries feature varying degrees of absence of the technology culture, and lack of qualified manpower and social carriers of technology, technical education has to look into this.

4. The developing countries:

The accelerating rates of advancement in science and technology are creating a sense of insecurity and threat, especially to developing countries. This results in ethical, social, economical, and environmental dilemmas. Developing countries perceive a threat to equitable social and economic development of their societies, consequent to problems of poverty, unsustainable patterns of consumption and production and non scientific and non-pragmatic utilization of their natural resources. As mentioned earlier, knowledge and its application in science and technology, have always been key components of development for all societies. In the present context and stage of rapid globalization, the generation and application of the science and technology and scientific and technological interchange, sharing and networking have become increasingly vital for economic and social development. Developing countries like India, still sorely lack the capacities to fully participate in the building of knowledge societies, and this, at a moment when the digital divide also accentuates disparities in development, excluding entire groups and countries from the potential benefits of new opportunities. Thus, an authentic global networking is not yet a reality for many. The issue may affect very much, the way different societies accept, reject and/or misuse certain technologies.

The speed of scientific and technological progress poses nowadays, new sets of

challenges. Information and communication revolution offers, new and effective means of transferring knowledge and advancing education and research, which promote the economic and social development of all people. As emphasized by the World Conference on Science, held in Budapest in 1999, international cooperation in the application of science and technology are crucially important in development, for both, developed and developing countries. I think, technical educationists of India have to take note of this, and think of more international collaborations in imparting technical education and undertaking research projects.

5. Socio-economic considerations:

Technologies adopted in the industrial societies make use of their characteristics. For example, they are capital intensive, of mass production, need high technical capabilities for operation, feature high value added, less raw material based. In the contrary, developing countries have the characteristics of scarce high technical labor, scarce capital, excessive unskilled labor force, weak information dissemination mechanisms, etc. Their industry is based, mainly, on a number of small production units (small and micro enterprises including, cottage industries).

Usually, there are alternatives for each technology. In many cases, some planners and technology exporters, in developing countries, believe that technology will solve the problems of their countries that cause them falling behind economically. And that, it will solve their social problems, too. Planners, sometimes, do not realize that the choice of technology is not an absolute technical problem, but it should reflect the objectives of the development plans and tools and should be closely related with the social structure of their countries.

One example of the effects of technologies on socio-economics of some developing countries, is related to the mechanization (or automation). That is the change from manual work society into machines society. These led, not only to economic changes, but also to social changes. Some of these countries rushed in mechanizing their agricultural and farming processes, without considering: (a) that most of their lands are divided into small pieces that are not suitable for the imported machines, and, (b) that poor farmers owning these pieces of lands, cannot afford buying such machines. Moreover, if they can afford to rent them, they will be renting from those rich and hence, socio-economical inequality in the countryside will be emphasized. And since the developing countries have scarce high technical labor, they will depend on foreign experts in maintenance and technical support. Hence, these developing countries tie their national economy and strategic product, viz. food production, with the external world. However, a close look to the technologies used in farming and agriculture in India would reveal how India has succeeded in adapting such technologies to their own environment and socio-economic situation.

Moreover, many argue that some technologies may cause unemployment. Automation in certain activities, which may be required in some countries because of shortage of manpower, may lead to more unemployment in developing countries. A different example of socio-economic impact of technology is that of the penetration of satellite TV in the homes. Observations have shown that this technology has changed the habits of the productive societies. With the reception of 24 hours broadcasting around the globe, workers, especially in developing countries, spend long hours during the night watching TV programs. This affects, negatively, their productivity during daytime. High intellectual societies may be able, relatively easily, to exert self control tools in order to overcome this negative effect. This implies that some societies may not be ready, yet, to interact positively with certain technologies, and hence affected by them, negatively.

An example of technology development that had negative impact on the socioeconomics of

an industrial country is the invention of quartz movement. This technology has proven to be less expensive and more precise than mechanical. The introduction of which changed the prestige of Swiss watches, which was based on accuracy that is a product of precision engineering and manufacturing. The result was the change of the locus of world watch production from Europe to Far East. World Swiss market, then, dropped from 50% to 15%. This reflects negatively on the socioeconomic status of Switzerland. It also had an effect on the society hereditary skills and worldwide reputation.

6. Political impacts:

On the other hand, politics affects technological developments. This is clear in military hardware technologies and space programs. A different example is the oil crises, which happened in 1973, created the needs of societies to reduce their dependence on oil as the major source of energy. Research and development activities have been accelerated in order to develop new technologies that may reduce fuel consumption and to adopt other types of energy like atomic, solar, wind, water waves and the like.

7. Impact of Technology on the Family System:

The Family System has undergone major changes through the decades. In the past, families used to be major production units, where everyone works shoulder to shoulder to produce or acquire the family daily needs, as well as they are responsible for keeping the order, defending, education and social development of the family's younger members. The industrialization made a major change; the large traditional family structure has been split into small fragmented units and lost a lot of its old characteristics. Its responsibilities are more to give birth of babies. The father lost a lot of his authorities, the children have more freedom, and the mother role has also changed. The new technological products such as Radios and Televisions, have made deep changes in the culture of the families. They have, to a certain extent, untied the family relations, who used to spend together the leisure times, and affected education and culture ties by canceling the role of the senior members of the family in educating the children and transfering them the old educational legends.

Consequently, the Government role also changed from being solely the defender against enemies, security and fairness keeper, to a bigger role in economy, social life, education, political issues etc. Government determines the development plans, choice of projects and the type of technology to be imported and acquired. In this, the government has replaced the most senior father in the old family structure. Internet, satellite broadcasting, electronic games and the like, have broaden the separation gaps between members of families, resulting in further weakening of families' ties. Population Reference Bureau, in Washington DC, showed that the percentage of people who live alone in the USA, is on rise. The number of adults between 25 and 44 years of age that have chosen to live alone independently have increased three folds in three decades. It also showed that fewer people are marrying, now, than ever. This may point out the negative effect of technology on the social life as we still look at it from the family life perspective. Perhaps, this issue is, still, not sever in some developed countries like India that still preserving its own heritage of cultural properties. But it might affect, in future.

8. Social Appropriateness of Technology:

At the time of development, any technology is appropriate with respect to the surroundings (society) for which it was developed, and in accordance with the objective function used for its development. This implies that same technology may not be appropriate in a different time, surroundings (society), and/or if the objective function changes. For a technology not to have a negative impact on a specific society, that is different from the one in which it has been developed, its appropriateness should be

considered. This includes the appropriateness with respect to this particular society's cultural, technical, economic, and environmental issues.

9. Ethics and Values:

Cultural aspects together with the values and ethics of the society, determine the potential of particular technology activities – to be accepted and absorbed by the society. One example is the Internet technology. The immoral usage of Internet may have different impacts on different societies. The severity of impact is dependent on culture, ethics and values of these societies. Moreover, broadcasting through satellite TV technology, of programs containing violence and pornography clashes with the values, cultural, moral and religious aspects of many societies. Cloning technology has raised many questions around the worlds. The dispute is, even, within different parties of the same society. The debate is focusing on at which point cloning technology clashes with, humane, ethics, values, and morals. In this respect, the raised general question about technology is, then, "Should there be a limit to technological innovation?" Such debatable subject raises the issue of moral risks within the technology context.

10. Engineer of the 21st Century

Perhaps, the most critical question facing the engineering academia today, is something far more fundamental: namely, what it will mean to be an engineer in the 21st century. As I have indicated, a number of factors will effectively change the skill-sets of the future engineers, as well as its approach to work, in general. As a result, societies around the world will need to consider how to make the most of these new opportunities and thus ensure that they remain competitive in the global marketplace. Indeed, without science and technology, no civilization could have evolved. Although, societal needs, expectations, ways and standard of living, habits, etc., may change with technology advancement, yet vice versa, technologies should, also, respond to such needs and expectations. I have also emphasized the importance of traditional and local knowledge systems as dynamic expressions of perceiving and understanding the world. Technology must become a shared asset benefiting all people, in all societies, serving as a source of power for social and economic transformation and for understanding natural and social phenomena. This emphasizes the importance of the exchange of knowledge, information and scholarship among governments and civic society, and that public participation in technological decisions, even at grass-root levels, is vital.

Therefore, capacity building of engineering students must be conducted not only in technical terms but also on a much broader basis, in order to empower them especially in relation to the applications of technology. One feels sorry, that in this era when man succeeded to exploit all his power to the development of science, deepening of knowledge base, and the usage of advanced technology, he is failing to develop enough spiritual and moral capacity to manage what he has developed. Does this explain, the disequilibrium state of ours, which created the challenges that the contemporary Indian society is confronting? With such enormous developments in all aspects of the materialistic world, with the absence of spiritual and ethical component, one may wonder, if we are happier than our ancestors. The technical educationists may have to think critically all those factors, which I have briefly pointed out in earlier sections.

The perspective, I feel and strongly believe, that technical education should seriously look for advancing rapidly the economic development and social welfare by educating the new generation in social relevant appropriate technologies in the contemporary world to attain superior and competitive advantages and future sustainability. Another dimension of technical education is, how to make technical graduates competent in designing and maintaining sustainable socio-economic systems. In today's context, a considerable number of contrasting

signs reveal that our society is currently contributing to the planet's collapse. Therefore, a new kind of engineer is needed-an engineer who is fully aware of what is going on in society and who has the skills to deal with ecological aspects of technologies. Technical education is *the essential* instrument to overcome the current world challenges and to train engineers, enabling them to build a sustainable economy and ecosystem. Thus technical education institutions have the responsibility to educate graduates who have assimilated an ethical/ moral vision and the necessary technical knowledge to ensure the quality of life for future generations. In relation to our graduating sustainable engineers, three main issues need to be addressed. They are: which sustainability competences must an engineer obtain at institutions, how can these competences be acquired efficiently, and which curriculum structure is more effective for the required learning processes?

Finally, I would outline here that to be a successful engineering professional, who can make a significant impact on society, there are essentially three aspects; namely the engineering aspect, technology aspect, technician aspect. The technical educationist must design curricula, which should integrate the following requirements for a socio-economic-culturally relevant engineer who will be competent to build sustainable world:

- Combination of general and specialist engineering knowledge and understanding to optimize the application of existing and emerging technology;
- Application of appropriate theoretical and practical methods, to the analysis and solution of engineering problems;
- Development of technical, commercial and managerial leadership;
- Undertake the management of high levels of risk associated with engineering processes, systems, equipment, and infrastructure;
- Perform activities that are essentially intellectual in nature, requiring discretion and judgement
- Exercise of independent technical judgement at an appropriate level;
- Assume responsibility, as an individual or as a member of a team, for the management of resources and / or guidance of technical staff ;
- Design, develop, manufacture, commission, operate and maintain products, equipment, processes and services;
- Actively participate in financial, statutory and commercial considerations and in the creation of cost effective systems and procedures; and undertake the management of moderate levels of risks associated with engineering processes, systems, equipment and infrastructure;
- Applying proven techniques and procedures to the solution of practical engineering problems;
- Carry supervisory or technical responsibility;
- Become competent to exercise creative aptitudes and skills within defined fields of technology;
- Contribute to the design, development, manufacture, commissioning, operation or maintenance of products, equipment, processes or services; and create and apply safe systems of work.

11. Concluding Remarks

Apart from all these, an emphasis for ecology study with an integrated perspective throughout the whole curriculum, is also needed. A separate course is needed to give the basic understanding of the challenges associated with sustainable development; to deliver tools and conceptual models for dealing with dynamic and complex

systems; and to attain a feeling of how things are interconnected. The separated basic courses on sustainable development delivered at universities today, often have an environmental focus. This needs to be balanced with more integration of social, economic, technological, ethical and moral aspects of sustainability. What I intend to highlight here, is that an engineering education curriculum should incorporate:

- Curriculum as a plan or blueprint to build the future generation leaders and creator of the new societal and economic order.
- Universality and objectivity in the real life problem recognition, identification, conceptualisation and solving.
- Focus on learner.
- View learning as holistic.
- Students as co-producer of knowledge.
- Seeking to develop a critical consciousness in students so that student become aware of the present ills of society and are motivated to alleviate them.
- Drawing significant contents from emerging technical disciplines and socio-economic problems of the day.
- Collaborative group work/projects.
- Emphasis on the process of learning, i.e. critical thinking and reflective articulations.

Ultimately, the objectives of an engineering curriculum appropriate to our nation must be directed towards developing sustainable technology leaders, social architects and ethical citizens by promoting high standards in scholarships, instructions and spirit of service.

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