EFFECTIVE APPROACHES TO ENGINEERING EDUCATION TODAY

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1. INTRODUCTION

Engineers today are being educated in a world bordering on crisis. "Human demands upon the planet are now of a volume and kind that , unless altered substantially, threaten the future well being of all species". Universities and their graduates must be significant actors if those demands are now to be shaped into the sustainable and equitable forms necessary for a wholesome future environment.

An unfolding worldwide scenario of free market economies and democratic functioning is shaping the business environment in the developed and developing countries. Engineers must be trained in this context where wholesome human development, a healthy environment and economic growth all harmonise together wholistically. An integrated approach to Total Quality Management, Human Resource Development is presented as a framework for analysing roles that engineers have to play in organisations. Key competencies required to be developed have been identified. The issue of values and ethics has also been discussed in relation to the Engineer's education.

2. THE CONTEXT OF ENGINEERING EDUCATION

Some trends that are emerging and which will shape the environment in which Engineers & Technologists will function are given below :

1. Rapid technological changes will continue to affect the way we think, work and manage. Information Technology is on the leading edge of these changes.
2. Growing civil turmoil and disturbances (natural and manmade) are evident all over the globe. There is a phenomenal increase in violence and class/group conflicts.
3. Internationalisation of Business. The need to understand and work with cultures, political systems, traditions and business practices different from one's own.
4. High obsolescence of knowledge. There will be a need to learn continuously from all situations.
5. A growth in the percentage of knowledge workers, i.e., people who work with knowledge and concepts using their minds rather than their hands.
6. The need to think beyond business and profits to wholesome Human Development and global well-being as the over-riding goal of all our work efforts.

3. THE NEED FOR A WHOLESOME ENGINEER

These trends have a direct bearing on the way in which Engineers ought to be trained. Some of the training needs that have emerged from the above are:

1. Engineers will have to learn how to learn. No single body of knowledge will provide them with all that they need to know in a rapidly changing world. The engineer of the future would have to have the capacity to make continuous

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learning a way of life.

2. Engineers will have to develop ;their leadership skills. They would have to design and initiate meaningful change with a firm understanding of the larger goals of mankind.
3. Creativity and flexibility in thinking to enable engineers to appropriately respond to life's challenges. This would also enable them to adapt to a rapidly changing world and deal with uncertainty.
4. Holistic Environmental awareness will have to be developed. Engineers would have to see the environment in its totality and understand the linkages between their work and sustainable development.
5. Interpersonal sensitivity and skill. The ability to listen to and fully understand another person and to assertively stand up for one's own rights would enable the Engineer to interact with people and also to negotiate creatively towards aligned outcomes.
6. Deep self-understanding and self-awareness without which the Engineer cannot respond without conditioning..
7. The Engineer will have to understand how values are formed and how the processes of value formation and change affects the culture of organisations, the nature of our work and society in general.
8. The Engineer would have to have the ability to manage his career choices and decisions with a deeper understanding of his own motivated skills, values and aptitude. He would have to have the ability to entrepreneurially dovetail his own growth/development, with that of the system in which he is working.
9. Finally, the Engineer must be able to manage his time, energy and attention in alignment to his priorities and life's goals.

4. AN INTEGRATING FRAME WORK

William R.Schowalter, Dean, University of Illinois, College of Engineering writes [1991] "If I were to pick a key word for this new decade, it would be integration". The need for inter-disciplinary approach to many of the technical problems that need solution is paramount. The engineers of the future must be able to easily apply diverse concepts to a specific problem, and clearly explain their ideas. They must be able to move comfortably among a variety of engineering disciplines. The approach has to be more holistic. This calls for a continued emphasis on oral and written communication skills as well as a broad liberal humanities education.

There is a tendency at present to use the tool that is handy rather than the one that best suits the job. The skills imparted by a liberal humanities education have been neglected over the past two decades. There has been increasing emphasis on specialisation and career oriented courses which have made students forget the wide range of interpersonal skills that a liberal arts curriculum provides.

An integrated framework of effective training must show the component skills that account for superior performance and how an integrated approach to train uniquely fosters these skills.

- Capable thinking-conceptualizing
- Communication, oral and written
- Problem solving
- Decision making
- Capacity for rehearsal, reflection and review leading to effective response to change.
- Leadership
- Forceful personal impact
- Administrative skills
- Creativity
- Interpersonal skills
- Advancement motivation

The integrated approach to effective training has to ensure that the curriculum provides the student the foundation and discipline to be a competent engineer - one

who could successfully engineer new products; who could manage people and projects; one who knew enough of the basics of accounting, marketing and humanities in order to successfully mentor people working with him and communicate effectively with others across other disciplines of finance and management etc.

Effective Training has to provide a mix of liberal education, basic science and mathematics, engineering sciences and engineering design. The engineers should be provided with a foundation for learning and growth throughout their careers, while at the same time being flexible enough to deal with problems whose components are technical, economic, social and political. In today's increasingly technological and economically global environment, an engineer must be multidimensional in his thinking and educated to take a broad international view in their approach to problems. Clearly, many of the problems that the engineer will encounter will be both technical and cultural, especially as the internationalization of business continues.

In the context of future development, it is well to recall the Halifax Declaration made at the end of a conference on "University Action for Sustainable Development", held at Dalhousie University, Halifax, Nova Scotia in December 1991. The opening sentences of the Declaration has been given in the introduction above.

The conference emphasized the mutual vulnerability of all societies and therefore resolved that energies and skills of people everywhere are employed in a positive, co-operative fashion. The crux of effective approaches in education and training emerging from inference are as follows:

- Commitment to sustainable development
- Better understanding of physical, biological and social dangers facing the earth.
- Ethical obligation of the people and enhancement of ethical awareness.
- Networking and co-operative working of organizations for effective action.

An effective training programme must produce ethically aware and value-literate engineers who possess the complete array of cognitive, behavioural and technical skills required to respond to the challenges and problems thrown up by rapidly changing technology and business environment. For this purpose, the course design must aim at integrating concepts from different fields of knowledge, integrate the issues of values and higher goals within the scientific framework; directly experience the reference point for personal and collective growth; and also learn the skills to improve creativity; interpersonal relations and personal well-being in their work as engineers in particular and life in general.

The artificial barrier between technical and liberal education must now go. The need is for a grand synthesis a program which is eminently feasible.

5. THE CHALLENGE OF GLOBAL COMPETITION & PRODUCTIVITY

There are three characteristics of a global free market which throw up a great challenge for the engineers of tomorrow.

These are COMPETITION; CHANGE; AND CUSTOMER CONTROL. The productivity of knowledge and service workers has also to be raised effectively because this will ultimately determine the competitive performance of companies. It will also determine the very fabric of society and quality of life in every industrialized nation.

Harry Cook has, in his new quantifiable theory of quality, concluded "that quality of product and return on investment are closely linked and that the profit to society of a high quality product is shared between the manufacturer and the customer".

The challenge of productivity can be met by taking an integrated view of Total Quality Management [TQM]; Human Resource

Development [HRD] and Customer Orientation as three facets of the problem of productivity with the human being at the core. This will mean a harmonious understanding of the interactions between the following elements.

1. Men	Producers; customers; service workers
2. Materials	Inventory control, just-in-time; vendors
3. Methods	Systems; processes
4. Machines	automation; computers
5. Measurements	Control; Quality
6. Minutes	Time Management; ON-Time; ordering priorities
7. Markets	Competition; customer delight; services
8. Money	Finance, capital profits

There has been a growing tendency towards higher costs, more capital investment, and more people with not much perceptible change in productivity as well as value addition. This imbalance needs to be rectified.

6. HOW TO IMPROVE EFFECTIVENESS

In the above context the challenge can only be met by improved effectiveness. We like to call it meta-effectiveness which encompasses the whole gamut of human effectiveness in its dimensions of skills, thinking, attitudes.

The following factors will have to be considered for achieving meta-effectiveness.

- Redefinition of the tasks. Eliminating what need not be done.
- Concentration on tasks and work which people are qualified to handle.
- Not doing activities that add little or no value to the product. Work has nothing to do with what these professionals are qualified and paid for. [More engineers are attending meetings than working on productive tasks at any time].
- What do we pay for? What value is the job supposed to add?
- Defining performance both in respect of quality and quantity is necessary,. Defining standards and building them into the work process is essential.
- Management and productive workers are a single team - truly a partnership. Everyone has a stake in improved productivity. Every-body is responsible for performance and productivity regardless of level, difficulty or skill.
- Let improvement be thought about, quality and performance bettered by those who do the work.
- Continuous learning has got to be a part of the process of continuous improvement. This is the Japanese "Kaizen" which means continuously doing better what we already do well.
- Teaching others the ways of improvement helps continuous learning.

With the above ideas implemented fully, productivity can be substantially increased leading to greater joy and satisfaction amongst the employees leading to self respect and professional pride.

7. CONCLUSION

Based on an analysis of engineers work situations and business environment in a global market, effective approaches to engineering education and training have been delineated. The approach takes care of the globally critical triad of wholesome human development - economic growth - environment. It is emphasized that the approaches of Total Quality Management [TQM], Human Resource Development [HRD] and Customer Orientation [CO] are to be integrated into providing an effective

training programme for engineers. Key competencies required to be developed have been highlighted. Engineering educators must hold forth a new vision based on these approaches for effective engineering education.