Technical education in India – An identity crisis

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In the context of economic and industrial development and its impact on society, the role played by engineers and engineering activities is extremely crucial. The social changes taking place in any country depend to a considerable extent on its technological progress. This is so because developments in technology offer the people new opportunities to achieve new goals and do things in new ways, bringing about improvement in economic factors and hence in the quality of life. These changes in lifestyle are reflected as social changes, the primary agents responsible for these being engineers and engineering activities. In the context of Indian economy, for example, statistics show that 35% of the industrial investment, 33% of the total industrial output, nearly 30% of employment and more than 30% of nontraditional exports are accounted for by engineering industries.

There was a time before the advent of space age, computer age and manufacturing age when life was much simpler and technology was not as complex as it is today. In those days, solutions could be achieved by individuals working at their own pace with a minimum of risk. But today the situation has changed enormously The world of today belongs to teams of professionals and specialists who can design, produce, operate and control highly complex technical equipment. An engineer is a professional He has gone through a carefully planned system of learning and training, which enables him to acquire a specific body of knowledge – all this being necessary to solve a host of engineering problems, which are an integral part of the development process. Irrigation systems, industrial operations, manufacture of goods, transportation and communication systems, electric power generation and its distribution are some examples of engineering problems

I am mentioning these aspects to create a framework within which technical education institutions and industries, whether Government-run or privately managed, must function in order to discharge their responsibilities efficiently Because of the tremendous opportunities that engineering provides, there is a tendency among the young aspirants to go in for technical education. The opportunities that existed 30 years ago in the field of engineering are nothing compared to those available today. The shrinking of the world today due to technological developments in transportation and communication has provided trained engineers opportunities even further. The limited number of Government-run technical institutions that were available in those days were able to meet the requirements that prevailed then. However, with the rapid increase in opportunities in the field of engineering, the Government, both at the State and at the Central level, was unable to keep pace with the demand for admission to technical education Added to this was our earlier concept of pseudo-socialism, which demanded that all promotional and developmental activities, particularly in the economic and related sectors, have to be either government-sponsored or government-controlled. Since sufficient resources were not available with the governments to start new technical institutions, the society was compelled to look for alternatives to meet the demand. Over a period of time, private enterpreneurs discovered this as a business opportunity, and today, as we all know the number of privately managed institutions far outstrip the number of government-run institutions A series of chain-like factors aided in the starting of these institutions. To start with, the Government could not accept the fact that technical institutions can be run and managed by private agencies Thus, the subsidy that was available to government-run and -aided institutions to make technical education affordable was not available to these privately managed institutions Consequently, in order to provide the basic infrastructural facilities, the managements of the institutions had to collect additional funds from students in the form of donation and capitation fees This aspect was abhorrent to the Central Government, since education began to assume the form of business. Since donation was critical to run these institutions, the admissions to privately managed institutions became divorced from the performance standard and quality of students seeking admissions Poorer the quality of students admitted, higher were the capitation fees collected Further, the money that was collected in the form of donation did not go entirely towards the infrastructural developments In many cases, only a fraction found its way towards this aspect, thus, these institutions did not qualify for affiliation due to a lack of proper training facilities. When the concerned Universities denied affiliations, a nexus formed between private management and politics, and a few governments at the State level took over the right of affiliation from the Universities Thus, affiliation of a college or an institution became a political decision rather than being based on quality and standard of a technical institution. This aspect also was highly unacceptable to the Central Government. Consequently, the aim at the Centre was to bring in legislation to limit the functioning and expansion of privately managed institutions This was rather unfortunate, since the nature of the problem was totally different, demanding altogether a totally different kind of solution The AICTE act that was enunciated about four years ago has become totally hamstrung Inaction, coupled with a lack of understanding of the real nature of the problem, has created today a messy situation Simple solutions are no longer possible. Mere legislative action without appreciating the true nature of the issues involved is going to complicate the situation even further Politics has become closely interwoven with the management of technical education It is in this context that one has to view the state of technical education in our country

Today, the number of privately managed technical institutions in the States of Karnataka, Maharashtra, Tamil Nadu and Andhra Pradesh is five to six times the number of government-run technical institutions. More than 30% of our national technical manpower comes from these institutions This manpower finds its place in defence services, R&D laboratories, manufacturing industries, maintenance organizations and a whole lot of productive sectors The quality and standard of these institutions, as far as their laboratory and other infrastructural facilities are concerned, vary over a wide range of spectrum, a majority of them lying towards the lower end of the spectrum. This is true not only for the privately managed or self-financing institutions, but also for a good number of government-run institutions Since the degrees are given by the concerned universities, the quality of the institution where the student studies is totally hidden. Over a period of about 10 years, more than 200,000 graduates have come out of these ill-equipped and poor-quality institutions and these graduates have found places in our economic and productive sectors, maintenance organizations, defence establishments, etc.

An impression may get created to the effect that given sufficient financial resources, laboratory buildings, class rooms, equipment, workshops and other facilities, etc., can come into existence, thus making the institution meet the quality and standards required. While these kinds of hardware and building facilities are no doubt necessary and can be made up through sufficient financial inputs, they are not the main critical issues The main issues concern the curriculum, its subject contents, teaching of design methodologies, problem-solving approaches, exposure to industrial and manufacturing processes, etc., which make technical education distinctively different from others About 30–35 years ago, when technology was not as complex as it is today and the amount of material that one had to study in engineering institutions was quite limited, the type of educational training that was provided had a degree of completeness and well-roundedness, in the sense that a person soon after graduation could take up a job and fit well into the stream of activities Institutions like Roorkee College of Engineering, Poona Engineering College, College of Engineering – BHU, Bengal Engineering College, College of Engineering – Guindy, VTI – Bombay, Engineering College – Bangalore, etc., stand testimony to this aspect Engineering graduates coming from these institutions in those years were well known for their competence and abilities The first IIT that came into existence, at Kharagpur, had also its educational pattern structured on the traditional lines of these institutions Over a period of time, with more industries coming into the scene with advanced technologies, the pattern of technical education started changing. It was IIT-Kanpur, which came into existence in the late fifties with the collaboration of a consortium of ten leading American institutions, that introduced a new curricular structure with a heavy science base to engineering education. 'Science-based engineering', 'a knowledge of know-why is better than merely a knowledge of know-how', etc, became the catch words. With the slow induction of computers and introduction of engineering science subjects (like mechanics of solids, mechanics of fluids, electrical sciences, materials science, systems dynamics, etc), engineering education began to assume a more glamorous front Traditional workshop practices, engineering drawing, industrial training, etc , began yielding, making way for the introduction of newer courses Still, one should give credit to IIT-Kanpur, since there was a strong conviction that design, which is the essence of engineering, should find a prominent place in the curricula, and hence design engineering was made a compulsory subject for all branches of engineering. And this subject, i e design engineering – whose aim is to teach students how to tackle open-end problems, which do not have unique answers, but multiple answers, out of which one has to judiciously select the most appropriate ones keeping in mind the severe constraints that prevail in a given environment – was carefully built into the curricula However, in spite of its tremendous importance in engineering education, as curricula underwent changes after every few years, the design-oriented courses soon found their way out, and today the engineering education has become a second-rate science education resembling more an applied-physics course, and completely devoid of its characteristic features and identity

Several factors hastened this process of making engineering education lose its identity. One was the glamour associated with the so-called scientific research in our country While liberal amounts of funds were made available to individual branches of science (like physics, chemistry, etc.), all branches of engineering were clubbed together for funding purposes Further, opportunities were available for persons working in 'frontier areas of research' and for those engaged in 'razor-edge research' to go abroad and participate in international conferences When our scientists are second to none in the world, particularly in USA or UK, how can one deny sufficient funds and liberty to travel for meaningful interactions? Surely, for the decision makers at the State level and the Central level, the choice was made very obvious! When engineers and technologies needed funds for their research, they had to call themselves engineering scientists and submit suitable proposals This was also convenient since doing software research was much more comfortable When Mr C. Subramaniam was the Minister of Science and Technology, and his department brought out the Science and Technology Policy document for discussion, there was more write-up on science and very little on technology. At several places, when the word 'science' was used, there was written in parenthesis that 'science includes technology'! It was also proposed in that preliminary document that a 'Science Research Council' be established. When this policy document was being discussed at the Indian Institute of Science, Bangalore, I argued that the concept was incorrect and that science did not include technology or engineering While technology makes use of science and scientific principles, to say that science includes technology is equivalent to admitting a total lack of understanding of the meaning of technology and the role it plays in the nation-building process Fortunately, when Dr A Ramachandran assumed the office of the Secretary of the Ministry of S&T, the 'Science Research Council' became the 'Science and Engineering Research Council'. But, unfortunately, the buck stopped there, and science and scientific advisors continued to dominate It is not so much the science that one is bothered about, but the fact that in the name of science, engineering was deliberately destroyed This was the first great pity

It would be a mistake if all the blame were to be put on scientists and scientific advisors. An opportunity was given to these persons and, like any ordinary human being, they tried to *protect themselves and protection was* given to them! The question is what prevented the engineers and technologists from putting their points of view? To start with, the engineers and technologists never had a foothold in the field of decision making As is the case with many developing countries, the glamour of science and the trumpeting that invariably goes along with it, kept the decision makers oblivious to the realities and the real factors that are responsible for the economic development and industrialization of our country. One should remember that our defence ministry has a 'Scientific Advisor', notwithstanding the fact that what defence requires is a 'Technical Expert' for the promotion of design, construction and operation of major nation-protecting devices like missiles, tanks anti-aircraft guns, combat aircraft, etc.! Further, when funds were denied for engineering research and developments, the faculty members in the IITs and other good institutions had already transformed themselves into engineer scientists!

Two agencies that could have come forward and asserted themselves were the Indian industries and the engineering professional societies. Both these agencies have been silent spectators to the gradual deterioration of technical education. In India, we have today, a fairly large number of engineering professional societies, like the Institution of Engineers, Institution of Electrical and Electronics Engineers, the Aeronautical Society of India, Indian Society for Technical Education, Computer Society of India, etc. Each society, with considerable membership, constitutes a reservoir of intellectual power. One would imagine that such a reservoir would be able to exercise enormous influence in shaping the society, or in influencing the decision-making processes of the Government. But, unfortunately, our Engineering Societies are totally ineffective. Most of them are preoccupied with their membership drives and their own examination systems. None of the societies have long-range goals or objectives enunciated and a plan of action to achieve them. They have exhibited minimum interest or concern in the field of technical education. When the number of technical institutions grew like mushrooms, the professional societies did not express their views either in support or against. When there is a continuous erosion in the standard of technical education, these societies have not taken a single step to rectify it. When the five-year degree programme was changed to a four-year degree programme (a reduction of 20%!), none of the societies expressed concern. When the M Tech/ME programme was reduced from 2 years to 1½ years (again a reduction of 25%!), the societies kept absolutely mum The indifference that is being exhibited even today is alarming for the simple reason that these societies do not have a view or an opinion on any critical issue. Naturally, the decision makers, both at the State and the Central level, have totally ignored these professional societies. This is the second great pity.

The industries, which are the user agencies of the trained technical manpower, have also remained aloof. But, business being their main objective, as soon as they realized that the type of education that is being provided in our technical institutions would not be able to provide them with any technical innovation or edge, they started adopting imported technologies on a mass scale, and as any industrialist today would say, they need persons only to keep their machines running and interpret correctly the blue prints supplied. Whether we call it screwdriver technology, or ready-made spare parts maintenance, the fact remains that the industries do not care whether it is a three-year degree programme or a four-year degree programme. A university degree certificate is all that one needs to get employment When seminars and discussions take place on industry–technical-institution collaboration, the first question that the industries ask the technical institutions is· What do you have to offer that is of interest to us? The answer is yet to come! While the technical education has remained stagnant and totally outmoded, industries have advanced by leaps and bounds. To realize this, one has just to visit the engineering trade exhibitions and then visit any technical institution in our country. Of course, *one does not expect by any means that* our technical institutions should be extensions of our manufacturing industries. But then, when there is absolutely no relation whatsoever between what is being taught and the needs of the industry and the country, the situation is frightening. Today, one speaks a great deal about ISO-9000, 9001, and our products competing in international markets with products coming from USA, Japan, Germany, etc.! How is this going to be achieved? With borrowed technology? With imported machinery? With better materials coming from abroad? Do we have a choice? How ridiculous can a situation be!

Recently, the Government of India has signed a contract with World Bank for Rs 4000 crore loan to improve the facilities and conditions in a few polytechnics in our country. A large contingent of experts came from the Canadian Community Colleges to advise the State Governments and the Central Government It has been pointed out time and again that polytechnic education in our country, as it exists today, has become totally irrelevant. Engineering industries have indicated that they do not directly recruit polytechnic diploma holders to the technician supervisory cadre bypassing their own senior shop-floor technician Many industries prefer ITI-certificate holders, train them and promote them later to supervisory cadres. Consequently, the polytechnic diploma holders have been pressing State Governments that they be allowed to join degree level colleges at the second-year level and become degree holders. What was urgently needed was a complete reorganization of the polytechnic education in consultation with industries Instead, the action taken now has not only perpetuated the existing unsatisfactory situation but also committed the nation to an enormous debt and waste.

The question that naturally comes is: What can one do now? Should we let the present state to continue and allow nature to take its own course or should we take some immediate steps to rectify the situation? The answer, of course, is no to the first question and a definite yes to the second But, then, the solutions are not going to be simple. We will have to go to the basics to identify the causes for the malady and apply *corrective measures at various levels.*

To begin with, we should never forget that engineering is a goal-oriented activity, the goal being to produce physical artefacts by judicious use of materials, men, time and energy for the benefit of mankind. This process by which ideas about needs are projected into ideas about things, and which in turn are translated into engineering prescriptions for transforming suitable resources into useful physical objects is called the design process. This act of designing is the essence of engineering. Sometimes a subtle difference is made between engineering and technology, where the former is said to deal with detailed planning involving creativity and innovative skills, whereas the latter deals with the tools and techniques for carrying out the plans. But such a distinction is neither desirable nor always possible since one is closely related with the other. If engineering education is to be distinctively different then the design content in the curricula should be substantial. In USA, Canada, and UK, the professional societies have prescribed a minimum design content, and if any programme fails to meet this minimum, accreditation is denied. In a developing country like India, where the industries do not yet have an R&D culture, the design content in our curricula should be quite substantial.

This design methodology should not be confused with the traditional courses in which problems have unique answers. Real design problems deal with open-end problems. From among a group of feasible solutions available to any particular problem, the ability to choose the right one which meets our constraints (materials availability, manufacturing capability, financial limitations, time frame, societal expectations, cultural bounds, etc.) is the hallmark of a well-trained engineer. Our engineering curricula and training programmes should aim at this. Without this, engineering education becomes meaningless. It is only when this ability coupled with creativity is inculcated in our students can the industries interact, develop and adopt newer technologies, and become competitive in international markets. While science definitely has a role to play in the engineering curricula, it cannot be at the expense of design training. Governments at State and Central level have been trying to promote entrepreneurial development and indigenous development of technology for many years. Most of the industries that have come up either in the small-scale sector or in the medium-scale sector have merely adopted the existing outmoded technologies or used imported technologies. Large-scale industries have been doing this all along. When the much needed design culture is not there in our technical education system, entrepreneurial development cannot take place.

Secondly, when one says that the products coming out of our industries need to compete with those coming from industrially advanced countries, one of the most basic factors on which this depends is our manufacturing abilities. Manufacturing engineering has become highly sophisticated and exposure to this subject has become absolutely essential. In today's context, design, materials and manufacturing have become closely integrated, and a mastery of this alone can make our engineering industries internationally competitive. These three subject material have to be carefully interwoven in our engineering curricula to give it a shape, form and strength.

Thirdly, the curricular patterns that are followed in IITs today are poor imitations of those prevailing in USA, but devoid of the much desired design content. This needs rectification since IITs alone can provide the desired leadership. Today, the resource materials needed for technical education are imported text books and foreign journals. The industrial development is also taking place on imported technologies. It is for this reason that these two bodies, namely, the technical institutions and the industries, have been growing in parallel without much interaction. Development and promotion of quality text books is absolutely essential if we have to stand on our own feet. The Quality Improvement Programme (QIP) of the Ministry, which was started during the fifth Five-Year Plan, has remained almost stagnant, with no imagination or modification. Funds made available for this scheme are quite substantial. For a fruitful return, this scheme badly needs a complete overhaul.

Fourthly, meaningful projects should form the culmination of an engineering education programme. In foreign technical institutions, these are called as 'capstone' projects, without which the engineering programmes are not complete. These problems should be realistic and should have relevance. Industries should come forward putting forth the problems that need creative and innovative solutions. Societal problems which need engineering solutions should be specified and sufficient financial resources should be made available. Without funding, creative solutions cannot see the daylight.

Next, those technical institutions which do not have the necessary infrastructural facilities and qualified faculty should be closed down; as otherwise, the ill-trained graduates from such institutions will not only form a national drain on the limited resources of our country but also become ineffective when they join our industries, defence establishments and other service sectors. In this context, the All India Council for Technical Education should wake up and constitute the National Accreditation Board and charge it with the responsibility of certifying institutions in a time-bound frame. This step is very essential since most of the universities in our country have become totally ineffective in maintaining quality and standards. The problems of universities belong to a much larger issue, which have to be tackled independently.

Many industrialists and Chairmen and Managing Directors of several industries have mentioned that the present MTech/ME degree programmes are meaningless, and do not meet the needs of the industries. This appears to be true since the current MTech/ME programmes are merely deficiency-make-up programmes for students coming from ordinary engineering colleges. The current trend of starting integrated ME programmes cannot be substituted for disintegrated BE degree programmes. Since MTech/ME degree programmes are fully financed by the Government of India, these programmes require a thorough re-examination, with strong participation from industries. Dr Nayudamma Committee report on post-graduate engineering education was a lame duck from the beginning. All the five institutes of higher learning, i.e. the IITs, had strongly opposed the recommendation of the committee reducing the four-semester MTech/ME degree programme to three semesters, which means cutting down substantially the time available for project work. But the scheme was pushed through with no intellectual discussions; consequently, the programme today is merely a poor make-up programme for the shortcomings of the degree programmes

Further, polytechnic education needs a through shake-up The World Bank loan will seal the fate of these institutions, unless the programme is stopped immediately and detailed discussions are held with the Confederation of Indian Industries, and employment opportunities for the diploma holders from these institutions are carefully evaluated The number of polytechnics which are extremely ill-equipped, poorly staffed and that are run in makeshift sheds are so large that unless some corrective measures are taken immediately the situation, which is already serious, will go out of hand. Since polytechnic education as it exists today has lost its relevance, the diploma holders from these institutions put pressure on the Government for admissions to degree level programmes, thus overburdening the already fragmented degree level institutions.

Lastly, professional societies should be allowed to continue enjoying themselves doing whatever they are doing now. They are good associations for relaxation and social evening hours.

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Geophysical and geodynamical aspects of the Maharashtra earthquake of September 30, 1993

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The Indian subcontinent is under severe compressive stress resulting from the collision of the northward moving Indian Plate with the Eurasian Plate about 50 million years ago, underthrusting the latter and producing the Himalaya mountain range and the Tibetan plateau. Whereas the Himalayan earthquakes are associated with plate collision, the earthquakes of peninsular India in the interior of the Indian Plate are primarily intra-plate earthquakes caused by crustal faults and epeirogenic vertical movements of crustal blocks.

The strong Koyna earthquake of 1967 with magnitude 6.7 on the Richter scale had unsettled the long-held view of the earth scientists in India that the Indian peninsular shield was a seismically stable region with a low order of seismicity. Both the Killari-Latur and the Koyna earthquakes had a very shallow focal depth of 5–10 km.

The vast Deccan Trap region is covered by basaltic lavas over an area of roughly 600,000 sq km in Peninsular India. The present author and his colleagues in the Geological Survey of India conducted geophysical investigations over an area of roughly 400,000 sq km in the Deccan Plateau of Maharashtra, parts of Gujarat, Madhya Pradesh, Andhra Pradesh and Karnataka, from 1965 to 1978 first under the International Upper Mantle Project (1964–1973) and continued under the International Geodynamics Project (1973–80).

The Koyna earthquake region was investigated by us immediately after the earthquake in 1967 employing gravity, seismic and magnetic techniques which brought out a deep crustal north-south fault zone passing through the western neighbourhood of Koyna which had apparently caused this earthquake. This fault zone comprising a system of parallel faults was subsequently traced all the way from the north Bombay coast to Ratnagiri on the coast in the south over a distance of 500 km traversing the Koyna region as reflected by the steep gravity gradient of 3–4 mgal/km (Figure 1). These first results were published earlier[1–3].

The results of the regional gravity surveys conducted in the. Deccan Trap region to the south of the Narmada river with the Bouguer gravity map were first published in 1972 by Kailasam and colleagues[3]. The Koyna-Karad region is brought out as a deep tectonic sag bounded by the Koyna deep crustal fault zone to its west. A number of prominent gravity 'highs' and 'lows' appear in the Bouguer gravity map (Figure 1) The pronounced gravity 'high' in the Nasik area in the northwest and Sangola area in the southeast indicates zones of marked uplift while the gravity 'lows' to the north of Nasik, and in the Kurudwadi area, Kaladgi Basin and the Koyna region indicate zones of marked subsidence[3, 4]. The residual gravity anomalies in these zones of subsidence are negative, suggestive of lower density segments underlying the traps, corroborating and confirming the Bouguer anomalies. These zones of marked uplift and subsidence of crustal blocks (Figure 2) are deep seated and subcrustal in nature, related to processes within the mantle[5–7]. The seismic depths to the base of the traps as computed by deep refraction seismic soundings at a large number of suitably located points all over the trap territory support this inference from the gravity data, inasmuch as relatively large thickness of traps is indicated in the zones of subsidence and smaller thickness of trap in the zones of uplift, suggesting that the strong gravity anomalies are due to deep crustal and sub-crustal effects, and not due to varying thickness of the high density trap (2.95 g/cc), the contribution of which is only small being of the order of 2–3 m gals generally in the area The thickness of trap as computed from the seismic data is of the order of 100 m in the marginal portions in the south and eastern fringes, increasing to more than 1000 m in the eastern