5. RESEARCH FOCUSED ENGINEERING COLLEGE EDUCATION : FROM HERE 2011 TO WHERE 2050

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Abstract

In this paper, it is argued that for achieving world class engineering education, research accompanied with teaching will take India a long way. This paper presents the role of teacher, objectives of university teaching, mapping status of engineering education on global plane, research status in developed countries and India, seamless firms and academic participation in research, etc. A few recommendations are presented like tenure appointment, reduced teaching load, research based promotions, attracting international talent, brain gain, research-fundraising, etc. Scope for further work is also defined. The paper, it is believed, will be of interest to all concerned.

1.0 Introduction

In today's ultra-competitive business environment, engagement, alignment and performance all go hand in hand. In the era of doing more with less, helping individuals bring their all to critical business tasks and keeping a strong focus on performance is essential. And education, a service sector, in Indian eyes a charity, is a charity business. Indian education system is comprised of primary, secondary, higher-secondary and tertiary education, the output of the preceding level is the input for the next, underscoring the interdependence amongst them. Over 220 millions students enroll in schools out of which roughly 14 millions go for tertiary education, i.e., Higher Education (HE). It is estimated that by 2020 India will need 500 millions technically competent work force and world will face shortage of such work force to the tune of 45-60 millions. Right from the time immemorial, education is considered as a key for the growth of an individual and community, as a whole. Indian education system has been facing enormous problems like access, equity, opportunity; gender compounded by regional, cultural, castes, linguistics diversity. India is a world class country in many respects like population, scientific and technical manpower, poverty, literacy, along with such paradoxical things as some world's richest persons belong to India, none of our institutes/university could appear in the first world top 100 universities, number of research publications/projects and patents at international level miserably low, India could not produce a single Nobel Laureate after independence, though India had before independence two, India a world class country without world class teaching, etc. The scope of the present paper is, however, limited to Higher Engineering Education especially its role in research. It is globally recognized that Technical and Management education is an engine of economy and prosperity and that classroom teaching must match with boardroom needs. And there exists teacher's dilemma: teaching vs research. Teacher, in fact, is the main actor

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(actress) in the drama of education, on the shop floor of Classroom Theater [1]. The next Section, therefore, speaks about teacher's job.

2.0 Engineering College Teacher's job

Teacher's job is neither repetitive (stereotype) nor discretionary but creative one. The outcome, in terms of job components and their weight-ages, of a brainstorming session on "Teacher's Accountability" recently successfully conducted can be summarized as [2]:

1. Teaching-Learning : 65%
2. Administration : 15%
3. Counseling : 10%
4. Self-development : 10%

The teacher's 40 hours weekly load prescribed by university/AICTE can be tentatively distributed as presented in Table 1.

In another survey, time spent (consumed) by a teacher on his /her job is reported as [3]:

- Teaching: Theory/practical : 55%
- Administrative wok : 30%
- Students' counseling : 15%

It is further reported that the weights of demanding requirements of a teacher's job can be something like as skill 64%, responsibility 23% and effort 13%. PADS approach considers teacher's role as a multiple one involving such job requirements as [4-6]:

1. Instructions (teaching), classroom and laboratory as well.
2. Management/Administration.
3. Learning resource development.
4. Research, development and innovation.
5. Self-development, acquisition of knowledge, skill and expertise.
6. Consultancy/interaction with industry.
7. Extension services.

However, it is necessary to carry out further research in the Indian context regarding job analysis, job description and job specifications of a teacher's job. Recruitment norms prescribed by AICTE, University, PSC, or other regulatory bodies can be considered as job specifications. Such specifications speak about minimal mental and physical skills required for a teacher's job. In ancient Indian literature, four attributes for teachers are advocated, namely, "Sadvartanam" (holy/pious/good conduct), "Vidwatta" (knowledge based on expertise, practice and experience), "Adhyapankaushlyam" (teaching skills) and "Shishyampriyatwam" (love and affection for

No	Component	Principal	HOD	Prof.	Associate Prof.	Asst. Prof.
1	Teaching - Learning	04	08	12	14	16
2	Administration	24	16	10	08	06
3	Counseling	08	10	10	10	10
4	Self - development	04	06	08	08	08
Total Hrs/Week		40	40	40	40	40

Table 1: Tentative distribution of weekly load of 40 hours [2].

pupils). The first and fourth one are universals and remaining two are path dependent, the call of the hour, market driven. The teaching skills have been shifting from duster-blackboard business to smart classroom using ICT tools to research based instructions. In tertiary education sector, like primary and secondary or higher secondary sectors, Indian education system is glued to the MacAulay's British education model, teacher-curriculum-student, meant for training the natives for running British administration smoothly in India. The Western developed countries have duly blended the education sector and needs of industrial revolutions. One cannot survive without the other. This is a missing link in Indian tertiary education sector. Though AICTE, UGC and other bodies have been emphasizing research as one of the essential elements of teaching occupation, it has been neglected for one or the other reason. Japan, for example, has rightly picked up this thread and teaching and research go hand in hand that made Japan so great, a super power. The next Section presents an overview of need and status of research as globally perceived.

3.0 Research Need and Status: An Overview

Research is the mother of development and economic prosperity. Research is the outcome of creativity and innovation that delivers new or improved technology to man for development. Industrial Revolutions-I and II are the milestones in the history of man. Since the mid-17th century, the dawn of industrialization, the institutes of technology and polytechnics have been functioning. The world's first Technical Institution, the Berg-Schola (today University of Miskolc) was founded by the Court Chamber of Vienna in Selmecbánya Hungary in 1735, followed by a few more in the following decade. However, this early "technological schools" were not a part of the Higher Education in the beginnings. The so-called BME University of Hungary (founded as "Institutum Geometrico-Hydrotechnicum" in 1782) is considered the oldest institution of technology in the world having university rank and structure. In the US famous examples include Harvard, Stanford, Caltech, MIT, Virginia Tech, Georgia Tech, Rensselaer Polytechnic Institute, Rose-Hulman Technology Institute, and Rochester Institute of Technology and many more [7].

Kenaw talks about aims and objectives of university [8]. Hall discusses education and further argues that technical education provides a societal foundation and technology should be described as the engine of social change.... As such University has obligations to provide students fundamental understanding of what technology is, how is it used and it affects their future. Technology and change go hand in hand. Technical education is, therefore, to business and industry, as physics is to aeronautics [9]. Henry [10] argues that it is erroneous to consider technology as applied science, in science we investigate the reality that is given; in technology we create a reality according to our design. A "technology object" is every artifact produced by man to serve a function. Engineering is not simply about applying knowledge from science to practice. Dewey [11] argues that knowledge is gained in engineering by doing things differently and in this way engineering knowledge is practical or "there was.... no definite art or science of modern bridge-building until after bridges of the new sort had been constructed". Dewey continues by pointing out that the theory developed as a result of a new achievement could not precede the achievement. Dewey's stance "education as engineering" adheres very well with an emergent approach "design-based research" or "design experiments". Bernhard [12] after discussing education as engineering science turns to philosophy of technology and mediated action: "There is little evidence to show that the mind of modern man is superior to that of the ancients, his tools are incomparably better". Bernhard proposes a model "Human ⇔ Mediating tools ⇔ World". Role of technology (artifacts) in every day human experience includes:

- Effect on human existence and their relationships with the world.
- To produce/transform human knowledge.
- How is human knowledge incorporated into artifacts?
- What do artifacts do?

How are the universities looking at research activities in their campuses and programmes? The strategic aim of the Technical University in Zvolen is to be a research university, providing a base to European research and educational activities. The developmental long-term plan (2003-2010) includes such elements as [13]:

i. Utilization of youth-intellectual potential.
ii. Science and research as a means to develop; preserve and disseminate knowledge.
iii. International cooperation.
iv. Development of the university integral organization structure and management.
v. Development and funding materials and equipment.
vi. Development of informatics and information of educational process, research activity, administration and management of the University.

The Kenawy's following recommendations are based on his research in respect of university education and its relation to development in Egypt [14]:

i. No quantitative expansion, increase quality.
ii. Integrate university and labor market.
iii. Improve research funding.
iv. Coordinate universities and research centers, no repetition of research, better cost cutting.
v. Climate for researcher, enhanced creativity.
vi. Support small businesses.
vii. Clear goals and philosophy of university.

Tokyo University of Technology, Japan, established in 1986 adopts the following three concrete educational ideas [7]:

1. Acquiring specialized knowledge and skills for public service.
2. Providing cutting edged researches, applying results to the benefit of society.
3. Ideal environment and equipment to conduct research.

In his blog, "R&D Spending for Economic Growth", May 18, 2011, Douglas French says China and India are catching up to the US in R & D spending, if research and science is put under the thumb of government, creativity is destroyed and bureaucracy takes over, one sure way to defeat the scientific spirit is to attempt to direct enquiry from above, all successful industrial research directors never direct research, no one would mistake a scientist for the average government bureaucrat or Rotarian for that matter, government is about planning and force, innovation is about discovery and freedom, the two don't mix. "I am a horse for single harness, not cut out for team-work," says Albert Einstein (http://blog.mises.org/16996/rd-spending-for-economic-growth/)

Inadequate industry-academia collaboration in India is one of the many weak links in building up enough R&D steam. MNCs are more proactive than homegrown Indian companies at Indian campuses. Surendra Kulkarni, chief technology officer at Dow Chemicals in India, says R&D perhaps hasn't been India Inc's cup of tea since it is extremely risky and expensive. As a rule of thumb, Kulkarni says he'd be happy with one patent application a year for every three scientists employed. The R&D investment patterns in India, more or less, mirror global trends. The computing, electronics and semiconductor industries account for almost a fourth of global R&D spends, followed by pharma, healthcare and auto. "The situation is pretty dire," says Naresh Gupta, managing director, Adobe Systems India. "There may not even be 100 PhDs in computer sciences across India. That's less than what you will find in one university in the US, and most of their research is fairly worthless". Maruti's Rao says that the lack of talent was so acute that it had to bend its rule of not hiring experienced engineers from rival carmakers. Hiring "outsiders" hasn't been a very happy experience for Maruti so far (Monday, December 27, 2010, R & D spending in India: An article from Economic Times,

Dhamodharan opines PhD is all about organizing one's life. How PhD holders are generally perceived is the critical issue, personal satisfaction would be the main factor in pursuing it [19]. The Engineering and Physical Sciences Research Council (EPSRC) is to spend £250 millions on establishing a network of centres to train more than 2,000 PhD students. The initiative is seen as a part of the international effort to update the doctoral training process. The degree of *Philosophiæ Doctor* is awarded in recognition of the recipient's original contribution to the sum of human knowledge. It can also be a test of endurance and character. So what is the rationale for the EPSRC initiative? There is said to be a shortage of scientists and engineers qualified to develop practical solutions to environmental problems, design innovative industrial processes and address numerous other real-world concerns. It's time to move beyond the almost mystical concept of the PhD as an ordination to the research priesthood.

A doctorate, e.g., Doctor of Philosophy (PhD), is an academic degree or professional degree that in most countries refers to a class of degrees which qualify the holder to teach in a specific field. In some countries, the highest degree in a given field is referred to as a terminal degree, although this is by no means universal (the phrase is not in general use in the UK, for example), practice varies from country to country, and a distinction is sometimes made between terminal professional degrees and terminal research degrees (such as the J.S.D.-*Juris Scientiae Doctor* or S.J.D.-*Scientiae Judicae Doctor*). The term *doctorate* comes from the Latin *docere*, meaning "to teach". The "licentiate" degree shortened from the full Latin title *licentia docendi*, means "teaching license". The dichotomy between 'teaching' and 'research' persists, in one or the other form, in most IITs even today. The idea that teaching is what the faculty is paid to do and research is one's own business, may be a hangover from the traditional engineering colleges which supplied most of the directors and faculty for quite some time. The 'teaching' vs 'research' syndrome emerges from time to time while apportioning teaching load (see Table 1) and at the time of promotions. With many of the faculty having foreign degrees and good contacts abroad, a new phenomenon that has emerged is the path of least resistance – do research when abroad and teach when back home. Lack of 'advanced facilities' provides a ready excuse. Evaluation of teaching, whatever its shortcomings, is hardly done in any institute, although this is *de rigueur* in all universities in the US.

In India, PhD is offered at both universities and institutes level. The minimum period prescribed is of 2 years but normally one completes PhD during 3 to 5 years span. PhD may be full time, with say 6 months residential requirements for external candidate. Fresh PhD holders are absorbed in public sector R & D organizations, a few in private sector and very few in academics. Since the last over 6 decades, IITs and NITs are playing a major role for turning engineering faculty into PhDs under QIP programmes duly supported by GOI by way of scholarships etc., over and above the regular salary they receive from their parent Departments. Though the IITs/NITs/Technical Universities Ph D norms are in line, university norms for PhDs vary from university to university in respect of eligibility of candidates, guides and examiners, course work, defense pattern, mandatory requirements like international publications, etc., which has led to a "who can, get PhD" syndrome questioning the quality of PhDs. Especially in engineering colleges, a very limited Ph D holders continue research in their own or allied fields as most of them acquire PhD for promotion only. When one is promoted to the post of Professor/

Principal at the age between 40-45 years, there is neither provision for further higher post nor research activities mandatory by law. Obviously, the research environment/activities, though required, in engineering colleges, is almost non-existing, most of the Professor/ Principals are stagnant, e.g., no post-doctoral contribution to the research field concerned.

4.0 Research Status of Indian Tertiary Education Sector after independence

In 1757, India's share in international market was 24.5%; Europe and US had together 21.4% [7]. MacAulay took every effort to de-root the Indian traditional but proven education models like Gurukul and Madarssa and established altogether a different British model for the elite class of natives. Four prestigious engineering institutes, first in Asia, were established at Guindy (1794), Roorkee (1847), Pune (1854) and Shibpur (Kolkatta) (1856). At the dawn of the independence, India had over 19 universities with a few world famous universities like Calcutta, Bombay, etc [7]. Today, India has over 390 universities; Japan and US have universities over 4000 and 3600 respectively [20]. During the period 1947-2005 there is thirteen-fold increase in number of universities, increase in the number of colleges twenty-six-fold and increase in GER from 0.7% to over 10% [21]. According to a recent estimate India's GER is 12.4% that is lower than the average of developed countries. For instance, average GER of developed countries is 45%, and 22% of China [22-23]. As reported, the premier institutes like IITs are facing paucity of faculty as good as 30% [24]. Prof. Chopra further states that in India we have 12 Science and Technology parks compared to 75 in Israel and 400 in China. The employability of Indian graduates is hardly 15% [20].

The UGC Annual Report 2007-08 aspires for 15% GER by 2012 and 30% by 2020. For achieving this target, MHRD has initiated increase in existing institute-capacity over 20% and establishment of a few dozens of new premier institutes of learning including Central Universities. As per the Approval Process Hand Book (2011-12) published by AICTE, the total number of institutes and student-intake in the country during the Academic Year 2010-11 is 10, 364 and 19, 54, 482 respectively. The estimated capital investment in infrastructure - building, amenities, gyms, etc.- is estimated to be over Rs 3, 83,468 crore, the national assets. The estimated number of faculty in the country is around 1, 30,300 out of which over 43, 000 need to be Ph Ds and remaining ME/M Techs and salary package for the faculty can be estimated to be over Rs 7800 crore pa excluding perks like EPF contribution by the institute [7]. These colleges turn out only (paper) graduates rather than begetting (in real sense) graduates having innovative and creative approach for developmental work. To turn out Indian engineering undergraduates/ graduates more competitive globally; bodies like MHRD, UGC, AICTE, NKC, etc., have been emphasizing research as an essential component of the teaching-learning process in engineering colleges. This has raised a dilemma: teaching vs research. Balram says that the present PhD regulation, i.e., "UGC (Minimum Standards and Procedure for Awards of M Phil/PhD) Regulation, 2009" is nothing but old wine in the new bottle, and that research does not happen by schedule, especially in engineering [25].

CRESY OMC Working Group has prepared report on Internationalization of R & D-Facing the Challenges of Globalization. The group has published a report: An Analysis of EU-Indian Cooperation in S & T. This report reveals among many S & T System in India, Central Government S & T Departments' shares of R & D expenditure (Table 2) and Chinese and Indian patent data (Table 3), etc. [26].

The planned increase in the numbers of PhDs needs to be in accordance with other developments in education and R & D policy [27-28]. Only 2 or 3 Indian institutes appear in the first five hundred World Top Universities after 300th position, none within first 100,

Scientific Agency	Percentage
Defence Research and Developement Organisation (DRDO)	30.3
Department of Space (DOS)	21.3
Indian Council of Agricultural Research (ICAR)	13.5
Department of Atomic Energy (DAE)	12.2
Council of Scientific and Industrial Research (CSIR)	9.4
Department of Science and technology (DST)	5.0
Minstry of Environment (MOEn)	2.6
Department of Biotechnology (DBT)	1.6
Indian Council of Medical Reasurch (ICMR)	1.6
Department of Ocean Development (DOD)	1.4
Ministry of International Technology (MIT)	1.0
Ministry of Non-Conventional Energy Sources (MNES)	0.1
Total	100.00

Source: NSTMIS (2006)

Table 2: Share of R&D Expenditure by Majour Scientific Agencies 2002-2003

	EU-Patents China	EU-Patents India	US-Patents China	US-Patents India
2006	113	106	970	506
2005	82	75	565	403
2004	69	70	597	376
2003	46	56	424	356
2002	26	18	390	267
2001	10	10	265	180
2000	11	7	162	131
1999	7	9	99	114
1998	7	8	88	94
1997	3	8	66	48

Source: EU-Patent Office and US-Patent Office, Annual Reports

Table 3: Chinese and Indian patents received at the EU-and US-patent offices

whereas, in the first twenty most of the universities are from US, remaining from UK, Japan, etc. [29]. The great Nalanda University in the 5th century was a hotbed of advancements. Where do Indian universities stand in innovation? Is there any relationship between innovation and universities? Or **is it that a strong ideas-culture is instilled only in a good university environment and the ecosystem around it, which includes startups and businesses?** It reminds an article by Prabhakar Raghavan, Head of Yahoo! Research wherein he says:

"India's real infrastructure problem–with no solution in sight–is not airports or electricity; it is the virtual nonexistence of graduate education and research in information and other crucial technologies. Consider this for starters: The US produces about 1,400 PhDs in computer science annually and China about 3,000. By stark comparison, India's annual computer science PhD production languishes at roughly 40. That number is about the same as that for Israel, a nation with roughly 5% of India's population size".

C.N.R. Rao, Science Advisor to India's Prime Minister opines that to be industrially and economically advanced nation, it needs to be technologically advanced and one cannot be technologically advanced unless one is scientifically advanced. Shri Kapil Sibal, MHRD, while addressing the 98th Indian Science Congress, 3-7, January 2011, SRM University, Chennai, Tamil Nadu, says that to promote quality in education and excellence in research, institutes have to set three generic principles: providing access to educational opportunities to all who desire and need it; affordability by reducing financial barriers; and building quality and accountability to ensure that what is taught is relevant and at global level, delivering good value for money and further says the National Innovation Council's (NIC) road map for the Decade of Innovation will help to have approach and methodology to create an inclusive and sustainable innovative Indian ecosystem [30].

Anita Mehta says that Indian scientific education is on a "slippery path". Three years ago the UNDP's Human Development Report 2001, which pioneered a Technology

Achievement Index (TAI), ranking some 150 nations according to their proven ability to absorb new and old technologies, offers hard evidence that India's much vaunted pool of trained scientists and technical personnel is shrinking. According to the TAI, the gross tertiary science enrollment ratio (i.e., percentage of school leavers entering the science stream) in India during the period 1995-97 was a mere 1.7%, 23 % in South Korea, 27.4 % in Finland (ranked No.1 in TAI), 13.9 % in the US, 5.9 % in China and 3.3 % in Malaysia. Moreover, the Human Development Report 2004 indicates that only 25 percent of all students enrolled in tertiary institutions are studying mathematics, science and engineering programmes (China's 53 percent), while the number of researchers engaged in R&D in the country is a mere 157 per million of the population (China's 587). Between 1980-2000 the number of scientific papers from India included in the Science Citation Index fell from 14,987 to 12,227, whereas, China's grew from 924 to 22,061 [31].

[* File contains invalid data | In-line.JPG *]Passi and Misra advocate a mixed approach – one that involves both quantitative and qualitative methods – for conducting research in distance education in India [32]. In EDUTECH. October 2010 issue under the caption "Research Boost in Indian universities" it is reported that in all metrics of research output China has left India behind. India encourages neither students nor students for research. While money is important to improve research, stakeholders need to be properly incentivised towards a common goal. Certain issues like dealing with versity blues: salary for research part (1/3 load) come from research, project proposal: pay enough overheads, erroneous mathematics: research funding policies, private institute do limited research, promotion problems: for IITs, one becomes professor in the age 35-45 but no next higher post, in private no evaluation, etc., need speedy solutions,

Shetty et al present results of an analysis of Higher Education and research scenario in ten state universities of India during 2000-2009, Calcutta University ranks first with average publication of 664 articles per year. The ratio of number of faculty to research publication varies from 1:0.05 to 1:1.19, Madras, Punjab, Rajasthan and Calcutta have ratio more than 1:1. University of Madras receives the maximum research funds of Rs 41.46 crore and gets rank first amongst ten universities surveyed [33]. Some suggestions made are: Indian universities need to be dynamic and adoptive, speedy accreditation, freedom to young innovative minds, have public-private partnerships, high level of funding for research, including contractual research. The institutes are under-financed and under-staffed. Emphasis on quality parameters is necessary in mushrooming of private institutions with the opening up of the Indian economy.

Dasgupta argues that research and teaching are inseparable. College teaching does not have much of a research component. In US everybody teaches at some point in their academic career. Even at Harvard, a Nobel Laureate has to teach undergraduates without affecting research. Interacting with young bright people boosts up research activities and integrates humanities with sciences [34].

The XI five-year plan (2007-2012) aspires for 14 world-class innovation universities in India, making India the global knowledge hub setting benchmarks for excellence for other Central and State Universities. World-class university means quality and excellence of its research recognized by society and peers in the academic world. India needs to be exemplars of quality and research beyond IITs/ IIMs [35].

The MHRD had set up a Task Force for rejuvenation of Basic Scientific Research in Indian Universities. Under Operation Faculty Recharge launched, 1000 faculty positions are being created that will be filled at national level through global advertisement, allocating Rs.144 Core. (UGC: Status of the implementation of the recommendations of the Empowered Committee for Basic Scientific Research in Indian Universities for 2008-2009). Jim and Tushar have proposed the following ten points agenda for India, emphasis being on increase quality and quantity of universities, to achieve its 2050 potential, 40 times that of today (see Fig. 2) [36]:

i. Improve governance

ii. Raise educational achievement

iii. Increase quality and quantity of universities

iv. Control inflation

v. Introduce a credible fiscal policy

vi. Liberalize financial markets

vii. Increase trade with neighbors

viii. Increase agricultural productivity

ix. Improve infrastructure

x. Improve Environmental Quality.

Italics by the author indicating education related factors.

Some think "massification" of education is a toll on academic staff standards [37]. It is reported that cooperation between firms and universities encourages firms to recruit PhDs [38], but all PhD degrees must have an expiry date, validity for 10 - 12 years [39]. UGC has announced on 12th May 2011 support for major and minor research projects for university and college teachers (*self-financing universities/ institutes not eligible for grants*) to boost up research programmes. Even retired teachers with Rs 12,000 pm honorarium can work as principal investigator up to the age of 70 years, no honorarium later on but required to complete the work (www.ugc.ac.in).

Based on the concept of cost based education, the Government panel suggests five-fold hike in IIT fees excluding hostel and living expenses, loan scheme for students, The current fees of IIT is about Rs 75,000-1,00,000 including hostel and all other charges,

(http://edu-leaders.com/content/government-panel-suggests-five-fold-hike-iit-fees-loan-scheme-students).

In an article "The Future of Higher Education", 17 May 2011, V, Sivaramakrishna, Manipal Education, says by 2020 India needs

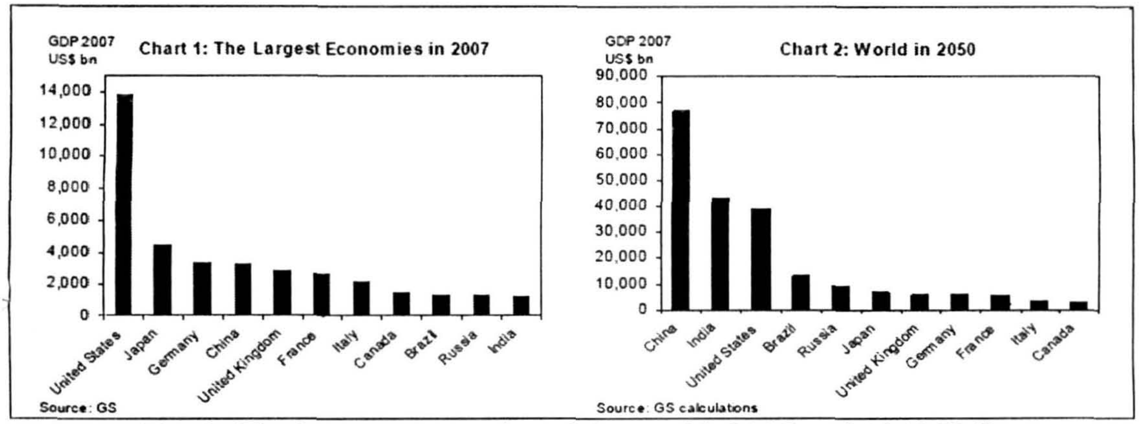

Fig. 2: The largest economies of the world: 2007 and 2050 [36].

a 500 millions strong technically qualified workforce, that by mid-2020 world shortage for skilled workers will be in the range 45-50 millions. India can be a supplier. Indian education system needs flexibility, convenience and an enabler to help move up in careers. Distance education unlike in the West is a poor cousin,

(http://www.edu=leaders.com/contents/future-higher-education).

Dr. Rahul in another article opines on entry of foreign universities in India, as the real test of a quality assurance system is to differentiate wheat from the chaff. Thus, government should focus on creating effective regulatory mechanism for monitoring foreign institutions instead of simply not allowing for-profit institutions to enter India. India needs the high quality teaching and research provided by research institutions but also the 'massification' that could be catalyzed by the next tier of institutions. Undoubtedly, the foreign universities bill is a positive development as it will improve quality and research practice in Higher Education. However, it has to be enacted in the context of the needs of India and the landscape of global Higher Education for delivering best results [41]. Running a major research university is more complex than running any global corporation. American Universities have pioneered the profession of education administration to manage its size, diversity and complexity. Yale earns $1.2 billions in revenue, 45 % of its yearly budget, Harvard. with endowment as $34.9 billions, and so on. In 2007, American colleges and universities raised US$ 29.93 billions through voluntary support as given below [42]:

i. Foundations: $ 8.59 billions (28.7%)

ii. Alumni: $8.27 billions (27.6%)

iii. Non-alumni individuals: $ 5.65 billions (18.9%)

iv. Corporations: $ 4.89 billions (16.3%)

v. Other organizations: $2.15 billions (7.2 %)

vi. Religious organizations: $0.38 billions (1.3%)

But fund raising is virtually non-existent in the Indian Higher Education system, one of the largest systems in the world. Indian system has no philanthropic contributors. The expenses on Higher Education have been declining from 12% in 1950 to mere 2% in 1990. Such and similar issues can be dealt with squarely by judicious blending of teaching and research in Indian institutes. The next Section is an attempt how can it be achieved.

5.0 The Way Ahead

In-spite of the un-precedent expansion (or massification) in Technical and Management Education during the last three decades in India, the Indian HE system has been facing such formidable challenges as access, accountability to quality and fund raising, diversity in language, economic status, religion, region, gender, etc. These issues can be resolved by planned changes in education sector including primary to tertiary. Tertiary education is the key for national economic development and prosperity. This sector is very "agile" world over. It has to function as an open system in order to quickly respond to ever changing market conditions and demands. Therefore, those universities/institutes maintain speed and customization are winners, while costs and quality of education are just qualifiers for engineering education. In view of this, universities/institutes in India will have no any other alternative but to adopt policy: equal weight age for teaching (instructions) and research. The education system design, therefore, needs to be organic, sensitive, proactive and innovative, and totally foolproof. Some of the basic issues faced by the Indian tertiary education sector are identified as listed below:

a) How to inculcate research component (activities) of national and international importance in our universities/institutes prevailing setup?

b) How to design the system with unbiased foolproof reward/punishment mechanism?

c) How to implement national policies and monitor the system?

d) How to improve Governance so that bureaucracy and innovation are not mixed up?

e) How to adopt the principle of inclusion?

f) How to go about fund raising?

g) How to maintain quality at less cost for mass tertiary education?

In view of the above, some suggestions are presented in this Section as given below:

1. Having accepted that institute is not only the instruction hub but also a research hub, three potential areas for research can be identified as:

i. Research related to functioning of institute like cost reduction, effective lesson planning, productive use of resources, administrative reforms, standardization, etc.

ii. Research to meet local industry challenges, especially MSME, community services, agriculture, etc.

iii. Research of national and international importance with emphasis on patenting and international publications.

2. To reduce the existing (on paper) teaching load to half, remaining half allocating to research. Normally, as per teaching schemes, per semester of 90 days, 16 hours/ week goes to theory and another 16 hours/ week for practical/seminar/project/tutorial. In affiliated/autonomous colleges, there would be hardly few teachers who achieve 100% teaching performance, i.e., the number of actual hours engaged in a semester is equal to the target hours prescribed by the teaching program of curriculum for the semester in question, nor few students with 100% attendance for the targeted hours, and in case of ME programs it is worse than worst. In fact, college students are hardly depending upon the faculty or classroom teaching for basic data/concepts due to easy access to ICT tools like surfing, coaching classes, connectivity with peers, etc.

3. Projects and seminars have become routine traditional culture of "cut and paste" business, totally contrary to their objectives. Introspect: Whether faculty proposes topics, reports are rigorously edited, any fruitful interaction among students. faculty and industry, any publication, patenting? This is the area to start with real research activity involving students and faculty in particular and industry, community in general.

4. To switch over to the Problem/Project Based Learning (PBL) model from the present Teacher-Curriculum-Student model. Treat faculty as a facilitator.

5. To use extensively the ICT and Lean Philosophy tools for integrating research with teaching (instructions).

6. Speed up university/institute accreditation process through NAAC/NBA/NGOs. Do not count only footage, glorified infrastructure, paper qualified and experienced - in terms of only number of years of service- heads (faculty) but count live and bubbling, talented, enthusiastic, quality performing heads involved in research. Install Key Performance Indicators for both teaching and research for faculty with appropriate tight monitoring, impersonal mechanism having 360^0 performance appraisal and feedback.

7. Like public sector, in education sector there exists no process management and performance management, no evaluation against target set, etc. Goals and objectives are there to be meted out [6] (see Fig. 4).

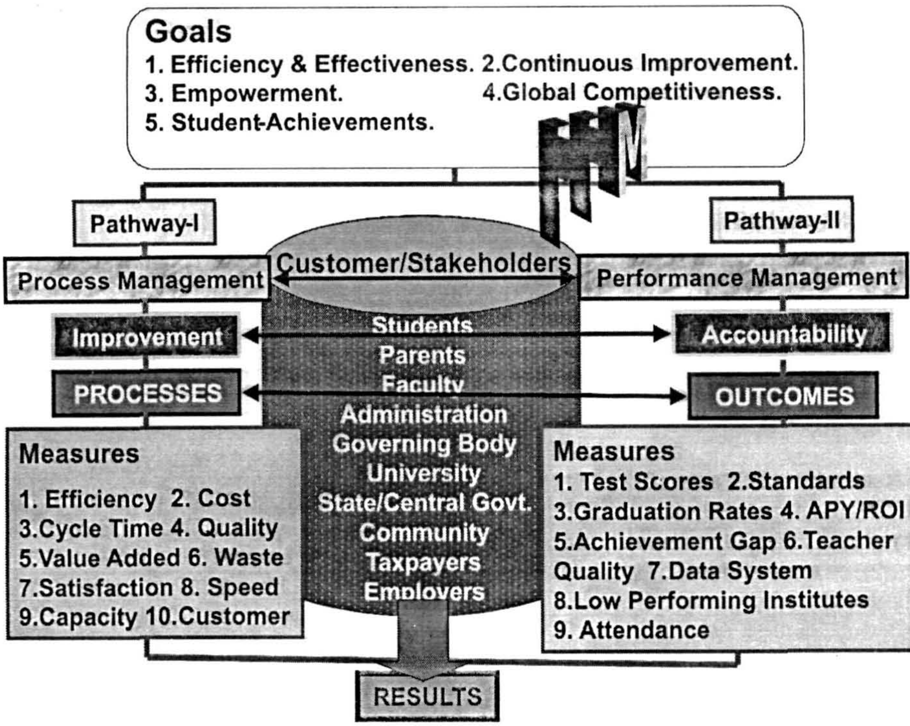

Fig. 4: Process and Performance Management [6].

It is imperative that design of all the processes related with academic, administrative or research activities of institutes need to be robust. Processes are strictly implemented and tightly monitored. And evaluate one's performance objectively by a right man, at the right time, in the right manner righteously. For instance, grading system, like, CGPA based on 5, 10 or 20 grades, for evaluating student's examination performance is being welcomed by universities/institutes including bodies like CBSE. Its success in terms of enhancing quality of education depends how does one earn credits and how is one evaluated on continuous and comprehensive basis, else it remains only a ritual, merely a reformation on paper or like a human body without soul giving to one psychological satisfaction of change, something new being done that is at par with international practices.

1. Salary must be linked with performance.

2. Recruitment of faculty must be unbiased and merit based. It is erroneous to assume that mere paper qualification of PhD speaks about research skills/capability. In fact, PhD is merely a certification to the effect that one is trained for research methodology in a particular field and s/he henceforth is capable to carry out independently (real need based) research in some field. It is, therefore, of utmost importance to evaluate the research work done after obtaining PhD, i.e. post-doctoral research work. This is rarely done while recruiting Associate Professors, Professor or Principal. By law it must be mandatory.

3. Faculty appointments like western countries need to be tenure based; only performer is allowed to go to subsequent tenures.

4. Education is not a profit-making business but a charity business. Hence, it is necessary to see to it that institute investment in crore of

Rs in equipment and laboratory need to be effectively utilized, at least 75-80 % capacity. This opens up areas for consultancy and research fetching additional revenue to both individual and institute. Faculty teaching without practical experience has no meaning.

5. Institute must have networking with other institutes, professional bodies like IIIE, CII, CSI, QCFI, etc., and both students and faculty interact with them frequently in the areas of their liking.

6. All universities extend vacation of 50 days/ year; earlier it was 70, and 90 days. Vacation needs to be either totally curtailed or students and faculty must get involved in some other related fruitful activity like field training.

7. One-year faculty cycle time needs thorough analysis so as increase more number of days that are academically productive. On an average institute's yearly cycle time appears to be like this:

- Sundays : 52
- Public holidays: 21
- Vacation: 50 days
- Casual leave: 12 days
- Non-teaching days (Prep): 40
- Actual instructions: 100
- Students activities: 40
- Days lost due to late admission/results: 20
- Unaccounted, campus interviews, gathering, etc. : 30

Automation, standardization, use of ICT tools, can certainly add more days that are academically productive. It is no wonder if one can get a degree in three years instead of four years, a national gain; sparing/saving thousands of youth-years for the national cause.

8. Each and every State must have a Technical University with networking with other universities/institutes at inter/national level. Encourage establishment of several State Universities.

9. To adopt US's brain gain policy, attracting talent internationally especially from India and China, that will prove rewarding for achieving global status to the Indian tertiary education. Tertiary sector needs to be enriched by attracting internationally reputed faculty, emphasis being on Indians providing them status, conducive climate and attractive compensation. Implement exchange programs for researchers.

10. The youngest CEO is 14 years old and the eldest of 94 years. AICTE/UGC have taken some steps relaxing existing retirement age of 65 years to 70 years in case of professors to meet the paucity of faculty that has hardly been found improving/maintaining quality of both teaching and research. However, there are no tight guidelines except age and not quality of such professors, bringing a very limited success in India. Therefore, the professors who are effective teachers and/ or researchers need to be incorporated in the system with no upper age bar, offering them good compensation say above Rs 1 lakh pm with tight performance checks.

11. Bureaucracy with over/lenient governance needs to be curbed out. Since bureaucracy has an upper hand many scientists prefer to be in bureaucratic setup occupying some senior post, thereby, India has been loosing many scientists/researchers. Innovation and governance should not be mixed.

12. Raising funds for research is a formidable issue in India, but not so difficult one to solve. Fund raising can be done through several means/agencies like alumni, religious temples, Ashrams (India having richest temples/Ashrams world over), State/Central Govt., faculty earnings through research,

loans, foundation (college Trusts), equity, Public-Private Partnership, local industry, tie-up with internationally reputed institutes, attracting private investment, etc. India is a land of gold. If pure are the purpose and implementation, funds will flow like anything. Institutes must have a separate budget head for research activities and its effective utilization be observed. All AICTE/UGC approved institutes need to be covered by various research schemes of Government.

13. Pre-service and in-service training is missing. Short-term courses of one/two weeks serve no specific purpose. A long term objective based field training for at least three months in a block of 2 years and objective based academic training courses at least for one month with examination can be devised. Both must be planned, need based and candidates performance must be evaluated.

14. To amend Company and other Acts so that industry will have to carry some obligations for institutes, especially research and training like Apprenticeship Act. Institutes need to be allowed to operate under Company Act or any other Industrial Act. Industry/institute and other research funding can be made IT exempt.

The above suggestions are not only applicable to Technical and Management Education in India, but also equally applicable to the entire spectrum of tertiary education sector including other faculties like Arts and Commerce, Science, Medicine, Law, etc.

6.0 Scope for Future Work

Several potential areas at various levels like institute (e, g., lesson planning, MRP, talent management, fund raising, etc.), local/national (e.g., for MSME: reduction in cycle time, materials requirements/handling (MRP), MH, WIP, etc.) and international (e.g., patenting, collaborative research, etc.) are prone to further research, thereby, meeting the objectives of HE.

7.0 Conclusions

This paper presents that to be an economical super power; Indian engineering institutes need to be research prone. It has been argued that with the rise of Industrial Revolutions, developed countries have been treating research inseparable from teaching. In those countries firms and academics go hand in hand, one cannot survive without the other. The paper presents research status of firms and institutes at international level giving some quantitative data and points out that India is far behind compared to those counties. The paper also presents research status of Indian institutes vis-à-vis the formidable issues the Indian tertiary education sector faces like massification, fund and faculty paucity, non-research culture, etc. In view of this a few suggestions like research an essential component of faculty job, integrating research with teaching, reduction in teaching load, research fund raising, research training, tenure based faculty appointment, while recruiting emphasis is to be given to what extent research contribution is done after obtaining PhD, discard mere PhD paper qualification for senior posts, amendments in Company and other Acts, research evaluation while recruiting faculty, talent management, attracting internationally reputed faculty, a real researcher will have no upper age limit to retire, etc., have been made. It is believed that the paper is of interest to all concerned.

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