2. LEAN EDUCATION MODEL (LEM) BASED ON INDUSTRIAL ENGINEERING APPROACH

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Abstract

This paper presents that through education and training, Human Capital can be generated fetching a country's socio-economic prosperity. The paper argues that education sector, being a service industry, needs to imbibe some business models like Business Navigator Method, Virtual Interactive Business Environment, Process Management and Performance Management, etc. Applications of IE approaches like work simplification, standardization, lean philosophy, JIT, TPM, etc., have been proving extremely rewarding in promoting effectiveness, efficiency and economics of manufacturing world. The paper, therefore, deliberates as to how and which IE approaches are to be deployed to education sector, especially tertiary, so that the out turn of education would be of quality at a lower cost with delivery on time. Few areas are scanned for this purpose, bringing out the benefits of IE approaches applied to education sector. To be globally competitive, IE approaches are shown to be yielding desirable results. The paper, it is believed, will be of interest to all concerned.

Introduction

One of the life-instincts of all the creatures in nature is educating and training their offspring. The outcome of such a training can be well expressed in the invaluable words of Bharatratna Sir M Vishvesvarya as "When a young man leaves the institution after a course of training, he should be clean in speech and habits, with a correct sense of patriotism, loyalty to the country, aptitude for initiative, love for self-help, appreciation of the value of time, respect for law and order, and knowledge of the value of right thinking and right living, sufficiently well-equipped to fall into a position in some business or other calling and be able to support himself "[1]. Innumerable examples are spread on the golden pages of man's history showing that the countries that educate their kids excellently are always proved to be progressive and dominant. And in the era of globalization and knowledge society, it is more so playing a key role. Education is aptly adopted as a foundation stone for the remaining four pillars of democracy, namely, judiciary, state, parliament and media.

With the passage of time, man for education sector, has developed and deployed several tools and models, like, Gurukul, Western, British (MacAulay), 2D Lowman model, e-learning, ICT

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enabled education, virtual class/lab/university, smart classroom, state/open/private universities, private-public partnership, etc [2]. Education sector-primary to tertiary- is now considered as service industry, striving hard to fully imbibe some relevant characteristics of manufacturing industry comprising of 8Ms vitamins, namely, man, machines, material, method, money, market, management and matrix (services and utilities). Several educational models like Problem Based Learning, collaborative and co-operative learning, e-learning, system approach, integrated approach, hybrid approach (balanced blending of e-learning and face-to-face approach), etc., are in vogue. All the models are focusing on three main issues: quality of education, cost of education and its on time delivery. Cost based education leads to profiteering or capitalism causing a rift between haves and haves-not, digital divide, etc., obviously keeping the last man of society at arm's length, depriving him from the fruits of development, jeopardizing the principle of inclusion, and the true evolution of human race. Universities and institutes, therefore, are becoming a vital part of local and global economies. The trend is:

a. General hum of industrial–research contracts.
b. Generation of spin-off companies, licenses and patents, a trend during 1990-2000.
c. Experimenting closely, forms of industrial affiliation (Ref: Nigel Thrift, 2011, The New Industrial Connectivity, Feb 14: http://chronicle.com/blogs/worldwise/the-new-industrial-connectivity/27862?sid=at&utm_source=at&utm_medium=en).

Naturally, man has been searching newer tools and models so that education can be imparted efficiently, effectively and economically, delivering instructions on time, with quality and at a lower cost. In this regard, the science of Industrial Engineering plays a vital role. Industrial Engineering can be defined as "It is concerned with the design, improvement and installation of integrated systems of men, materials and equipment. It draws upon specialized knowledge and skills in the mathematical, physical and social sciences together with the principles of methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such system" (American Institute of Industrial Engineering, 1955). In view of this, application of some Industrial Engineering (IE) approaches, science of continuous productivity improvement (of continuous value addition), to education sector is expected to be highly rewarding. The next section deals with the present status of higher education system in India.

Indian Higher Education scenario

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 [2]. Today, India has over 390 universities; Japan and USA have universities over 4000 and 3600 respectively [3]. 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% [4]. 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 [4-6]. As reported, the premier institutes like IITs are facing paucity of faculty as good as 30% [7]. 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%. However, from time to time, some educational models are being devised. For instance, some major education models are: National Education model advocated by sister Nivedita [8] and "Rashtriya Shikshan" devised later by Lokmanya Tilak in early 1900s, Nai Talim by Mahatma Gandhi [9], Radhakrishnan, Kothari, New Education Policy

1986, Yashpal, etc. Nevertheless, save a few institutes that appear after 300 ranks, none other universities/institutes appear in the list of the first 500 world famous universities. In the age of globalization and knowledge society, one talks about benchmarking and accreditation; it may be NBA, NAAC or ISO 9000 certification. Malcolm Baldrige National Quality Award, introduced in USA in 1987 like industry, is adopted in education sector too. Its seven criteria are:

a) Leadership.
b) Strategic planning.
c) Customer and market focus.
d) Information and analysis.
e) Human resource focus.
f) Process management.
g) Business results like institute/university performance, improvements in its key business areas, etc.

Fig 1 and 2 present other two models relevant to education sector, i.e., PPM and EYE. In a competitive globalization education market, India needs to struggle hard for increasing the number of institutes/universities with all due care for easy access, equity, quality and excellence in research with moderate (or no) fees treating degrees as "social" goods rather than "private" goods [10]. Deploying the IE approaches like industry to education sector can hopefully solve such and similar issues, like, quality, cost, access, equity, etc., being faced by Indian Higher Education system

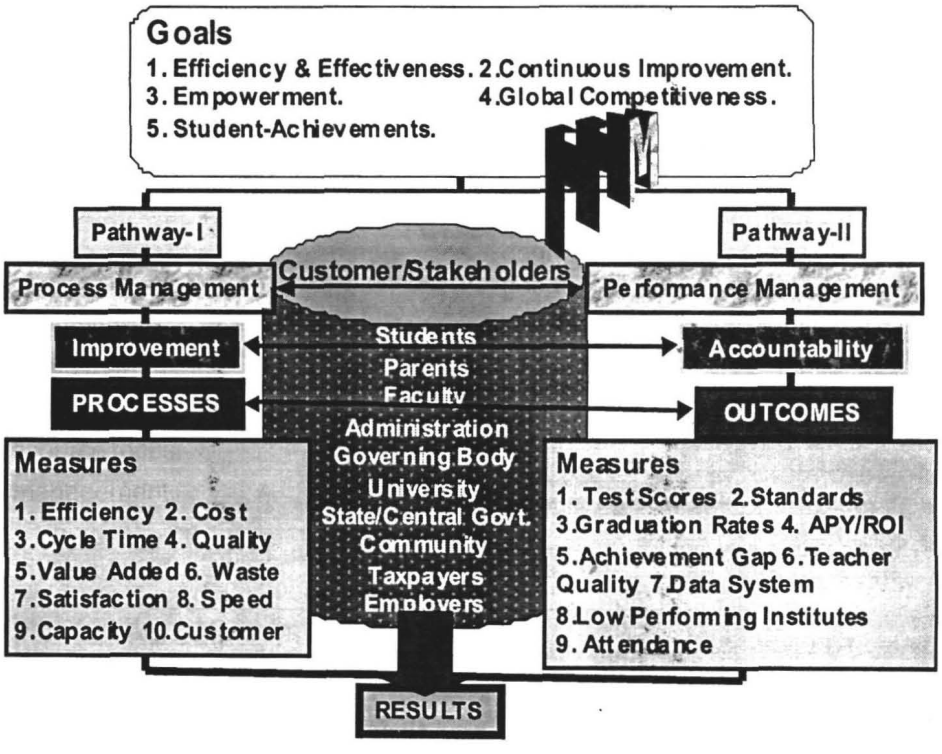

Fig. 1: A model for process management and performance management

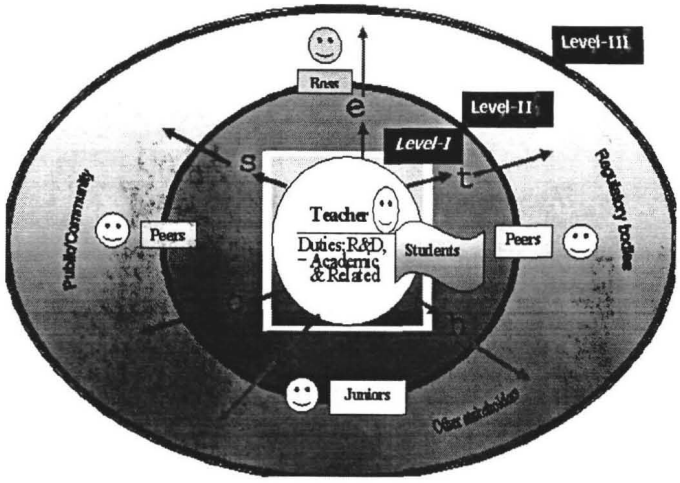

Fig. 2: Ethics your Eyes (EYE) Model Proposed: Deontology & Professional Ethics.

IE and business navigator method

With the emergence of ICT and associated sun-rising technologies, an unprecedented sea change is taking place in education sector. Today, one talks about smart and virtual classrooms, classrooms without walls, virtual lab, virtual university, etc. In fact, education providers treat this industry as a business. One of the business models is Business Navigator Method (BNM) [11, 12]. It leads to management development that combines both case method and business simulation games and it presents a framework integrating computer and telecommunication technologies as a development tool. Virtual Interactive Business Environment (VIBE) is a key to BNM, a realistically simulated business context inviting learner to explore step-by-step in the course of a "virtual visit". VIBE helps realize a case study transforming it into real experiences, like, wandering through building, look for information, meet people, etc. In a VIBE, business context is mapped on to three interconnected navigation levels; namely, physical, organizational and information (see Fig 3).

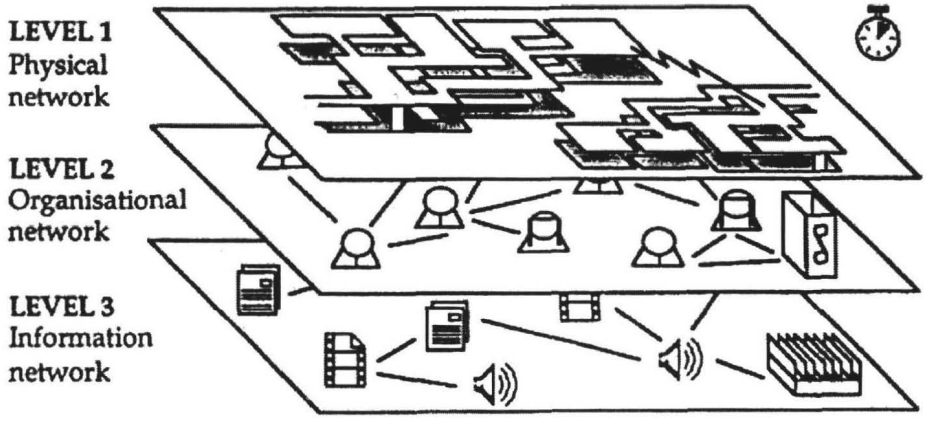

Fig. 3: Interactive navigation takes place on three specified levels (12)

The concept of navigation on the first, physical level, is simple to understand and straightforward, i.e., moving/interacting through a network on physical infra-facilities (see Fig. 3). At the second level, navigation is extended to a network of "information owners", i.e., the agents or managers, so to say, or formal organizational structures, inter-and-intra-organizational relationships, and personal networks of individual organizational actors. At the third level, the information sources associated with the "information owners" are accessed, on request, through such means as video/audio interviews, documents, organizational reports, and extended database. The pedagogical implications of BNM can be summarized as given below [12]:

a) Learning how to handle complexity like information overload or social interaction.

b) Learning how to deal with constraints like time, skills and perspective.

c) Learning to develop efficient information gathering and interpretation strategies.

d) Understanding the role of information in an organization.

e) Richer discussion material given the difference of individual strategies.

f) Richer experience, case writer perspective rather than case reader perspective.

The five pedagogical objectives of BNM are:

1. To provide a systematic approach to modeling, a dynamic, lively image of a global organization.
2. To enable to manage two resources efficiently: time and information.
3. To reflect on the speed and quality of decision one takes.
4. To focus on training in such areas as problem/opportunity identification, interpretation and sense-making skills in addition to enhancing analytical and problem-solving skills.
5. To significantly enhance the quality and diversity of ensuing discussions and reflection through such means as group discussion and comparison of experiences or bench marking.

Obviously, the BNM model, integrating three networks as mentioned earlier, duly associated with PPM and EYE models, is expected to cater to the needs of education, both on local and global planes. Nevertheless, for process management and performance management related with networks, IE approaches can prove to be of a great help. In fact, IE aims at continuous improvement. It starts with such tools as motion economy, micro-motion analysis, work simplification that are further extended to such tools as 5S, 3M, Kaizen, Kanban, TPS, SMED, JIT, Lean manufacturing and six sigma. In a real sense, lean thinking encompasses all these tools in one or the other form. Thus, hopefully IE approaches will not only meet the objectives of BNM and other models but also can positively response to such issues as access, equity, equality, lower cost with quality and reaching unto the last man in the society.

Deploying IE approach to education model

Mahatma Gandhi, the first IE guru of India, always wore a watch on person, and continuously experimented innovatively with processes, be in kitchen or of national importance. It was Mahatma Gandhi who introduced Nai Talim, entrepreneurship, lean philosophy (e.g., simple living) and self-dependence- self-support that India lost under British regime. IE approach is being deployed since early1800s, from the days of F W Taylor, the father of scientific management. IE approach is mainly used in manufacturing and less in service sector. However, IE approaches application in education sector is subjected to additional features, at least two, not seen in industry world, namely, education deals with live-

stock- both the raw material (students) and operator (faculty)- and its planning horizon is very long, at least 25 years, one generation as against the short (daily)/long (5-10 years) range planning in industry. The true outcome/fruits of education are seen only after 25 years, examinations results, accreditation or employment/placement just by-products, not necessarily the real determinants of quality education [13]. Table 1 presents a list of a few potential areas in education sector where implementation of IE approaches can prove rewarding.

Sr. No	IE Approach	Potential Areas	Potential Benefits
1	PDCA cycle	Classroom teaching, administration, Lab work	10-15% time saving, material cost saving 5%
2	Work simplification	Library books issue, assignments evaluation, experimentation, office procedures, unit test, industrial visits, intra-inter communication.	10-20 % time saving, lead time reduction, ease of supervision, effective communication.
3	Standardization	Lab-books design, seminar/project template, lecture notes, MRP. Dept. load, number of faculty/staff, and talent management and acquisition.	Effective database, MRP, cost reduction 10-20 %.
4	Kaizen teams (Quality Circles)	All areas of functioning	Continuous improvement. (or value addition)
5	Cause-effect diagram	Results monitoring, Hostel Management, ragging/addiction/ drug prevention.	Identification of a process factors and sub-factors.
6	5S	Workshop, Labs, library, sanitation	Neatness, easy retrieval, orderly approach.
7	3M (Muda, Mura, Muri)	Classroom/lab teaching, workshop/ office procedure,	Lead time reduction 20-30%, waste elimination.
8	Lean Thinking (philosophy)	Stores, records, gym, sports, events	Material saving 10 -30%, lead time reduction, 10 - 20%
9	Zero defects	Administration, service books and other records, lab/theory conduct	Quality services, moral boost up
10	Jidoka	Vital processes	Individual empowerment.
11	Poka-Yoke	Trivial and other main functions	Mistake-proofing, Right First Time
12	Andon	Principal and HOD	Real time quality control.
13	SMED	Switching over to new batches/tasks	Time and money saving,
14	KANBAN	Inventory: stocks and materials	Cost saving 10-20%.
15	Gembutsu	Principal, HOD, Librarian, W/S	Quantitative database.
16	TQM	Institute wide scope involving peon to principal.	TQM culture, self - leadership.

Table 1: A few potential areas of education sector, where IE approaches can be rewarding.

Though this section deals with IE based Technical and Management education in India, the approaches/methodology used therein can certainly be extended and deployed to other level of education like primary. Fig. 4 presents a pyramid structure of Indian Technical and Management education system that will reinforce the design of three networks of BNM.

the main players in education system. Institute is the shop floor, point-of-use, where the actual drama takes place (see Fig. 5). Hence, this paper focuses on institute functioning related with its three networks of BNM model.

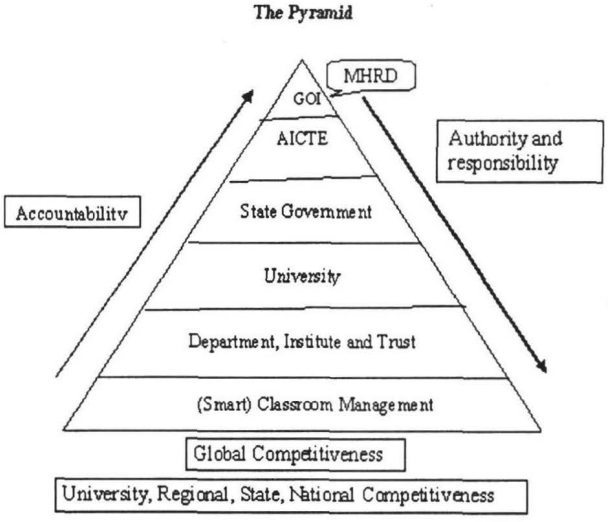

Fig. 4: The pyramid of accountability (14)

State/Central government, AICTE, UGC, university and Trust are the regulatory bodies that are expected, in public interest, to adopt such strategies as inclusion policy and national interests. Regulatory bodies and institute are

The first two networks of BNM model, i. e., physical and organizational, are easy to understand and in education system, these are well defined. However, the third network, information is more complex and complicated,

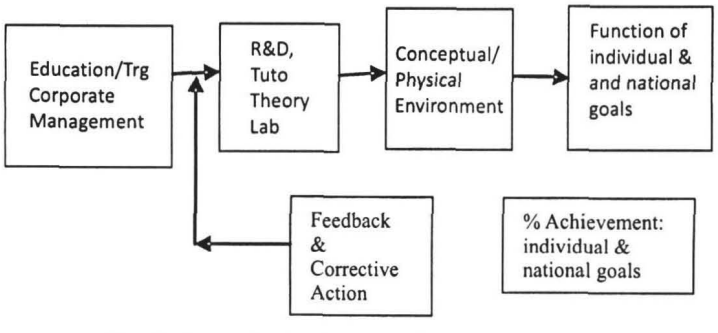

Fig. 5: A model for institute (based on PDCA cycle) [14]

compared with industry for it does not include only information (communication) at various points like principal's and Head of Department level or any other level but also includes the heart of matter, teaching-learning process, its data base, mode of instruction-delivery, etc. The next section illustrates some cases using a few IE approaches in tertiary education sector.

Some illustrative Case Studies

This section presents a few real life cases how the functioning has been improved by deploying IE approaches to some elements of education system.

Physical Network: GT layout approach

AICTE has given an in-depth thought to infrastructure including classrooms, labs, library, amenities, circulating area, residential quarters, etc. However, the principles of cellular (Group Technology) layout are rarely applied in laying out institute building. Department can be a cell having its own office, labs, classrooms, library, and other amenities facilitating stream line flow of communication and travel of its constituents, students, etc. Cells having high relationships will be neighbors. This layout facilitates design and planning of other two networks, namely, organizational and information. In fact, the three networks are overlapping each other. This facilitates intra-inter-cell smooth flow (information), minimization of inter-cell flow, safety, ease of administration including control, less floor area requirements, etc.

Organizational Network

The institute as a whole ought to have value and mission statements, a set of well-defined objectives, policy document, quality policy and priorities. Departments need to align their goals with the objectives set by institute as a whole. Best-in-practices like having Job Evaluation manual, performance appraisal, pre-in-service training, industry connectivity, documentation, procedures, relationships, rules and regulations, code of conduct, etc., can be administered. Recruitment, pre-in-serving training, employees' performance appraisal and industry connectivity are the four vital areas of institute functioning. The first one is diluted, and remaining three are almost missing. For example, cost to company (C2C) in case of some middle level faculty and principals in old pay scales is in the range Rs 60000- 100000 pm and Rs 1.5-2.0 lakhs pm respectively. Recruitment of faculty is a critical area of staffing. Not only that recruitment is strictly to be as per AICTE norms set, but also such tools as Video Enabled Talent Acquisition be used, securing top talent, enhancing employer brand, reducing costs, improving efficiency and increasing stakeholders' satisfaction, e.g., for an investment of just $2,500 per month, Brown-Forman saved over $200,000 in the first half of 2010 alone [15]. For 300 student-intake the employees C2C is around Rs 6.5 crores pa (see Table 3). This workforce is at the point-of-use where several IT tools can be deployed for efficient, effective and economic institute functioning with quality output at a lower cost with on time delivery. Some of the areas where such IT tools can be used are briefly discussed in the sections to follow.

Cause-effect diagram (Ishi kawa)

Fig. 6 presents a cause-effect diagram applied to a college before going for accreditation. (see on next page)

Teacher's Cycle Time reduction

A teacher (Assistant Professor or Lecturer) spends his/her 55% time in institute for teaching [16]. Teacher's one year cycle time can be expressed as [17]:

$$EAh = Th + Pr + T1 + T2$$

Where,

EAh : Total hours/year for educational activities.

Th : Total theory hours/year.

Pr : Total practical hours/year.

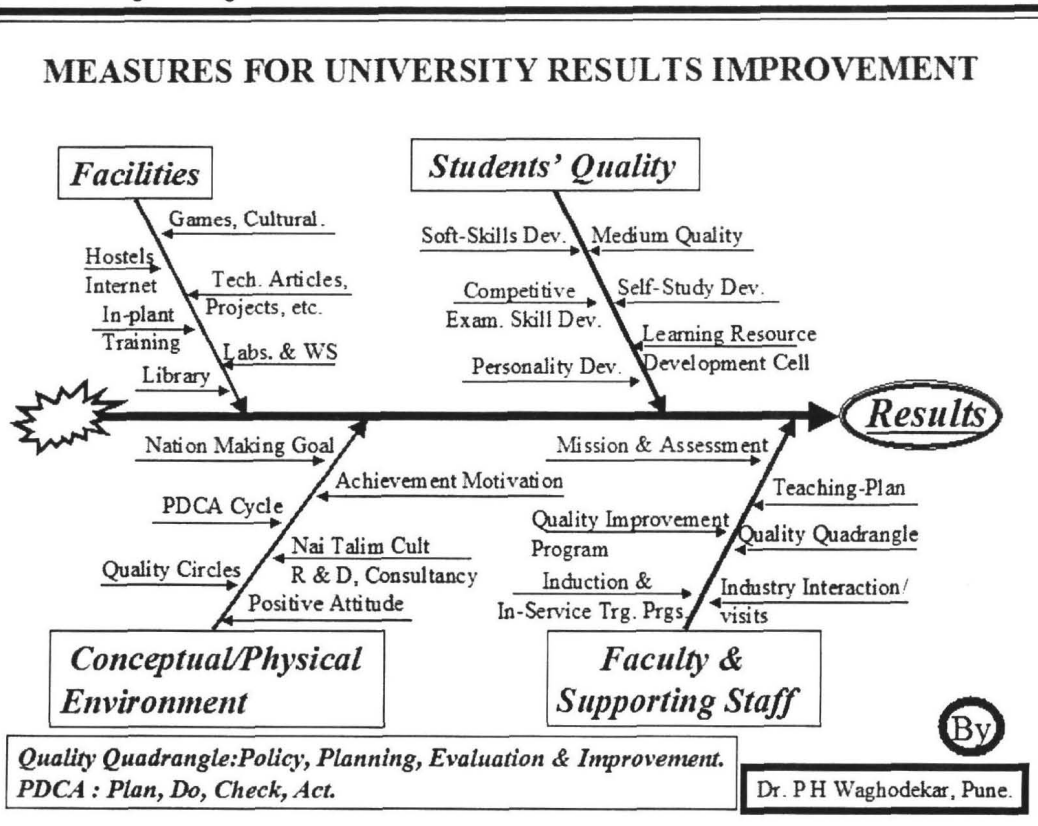

Fig. 6: Ishikawa diagram for institute.

T1 : Set up time in hours for lab/ workshop, timetable, administration, etc.

T2 : Hours for administration, co-curricular and extra-co-curricular activities, excluding time spent on conduct of examinations.

Some Research Findings on Classroom Time Management

The vital outcome of classroom management (CRM) is its enhanced productivity that can be measured in terms of units of time productively (optimally) used in classroom operations [14]. Deployment of such tools in CRM as lean thinking, PDCA cycle, students-peers-parents-boss-feedback (360°), continuous improvement, Gantt chart, principles of work simplification, lesson planning, etc., can greatly enhance the productivity of classroom operations, thereby, in turn, automatically improving the quality of education [14]. Research findings in respect of classroom time management can help unfold the ground reality how a teacher manages his/ her time in a classroom. Some findings are presented below:

- One-year cycle time analysis for a teacher shows that time spent by a teacher on direct teaching and related activities, as reported, is 31% on teaching-learning process, and 69% on other educational activities. Further, of the 31% time on teaching-learning process, its 10% and 90% times are spent on actual teaching and on other teaching related activities respectively, i.e., actual teaching in a conventional mode is hardly of 3.1 minutes in 100 minutes cycle time like 5 minutes actual cutting time with 100 minutes cycle time in a conventional factory [14].

- Researchers have found a high % of time spent on non-instructional tasks.
- Past–teachers believe that students need to be kept busy for good student behavior (do worksheets/seat work).
- Research reveals that students in classes where teachers spend more time on instruction, learn more.
- Today teachers must make sure that students are engaged in productive learning (plan activities that are authentic and motivating).
- For utilization of time in classroom operations and management, see Table 2 below.

% Time spent on / Use of time	Active Instruction	Organizing	Monitoring	Off – task
Effective use of time	50	12	35	3
Average use of time	12	50	26	12

Table 2 : Effective use of classroom time in percentage(14)

a. The average teacher spends far too little time for actual teaching, compared to the effective teachers.

b. Effective teachers are rarely off-task.

c. Effective teachers take care of organizing activities (checking roll, making assignments, collecting papers, etc.) more quickly.

An Institute is required to function 180 days in one academic year or 15 weeks per term. Actually, one term usually happens to be between 10-12 weeks. To make up this time-loss, some teachers turn to power point presentation for class instruction and making available old submission work to students. The curriculum prescribes theory and practical load put together in the range 30-35 hours/week per programme. Most of the teachers end up with 40 to 60% efficiency both in theory and practical load assigned. To overcome this academic loss, tools such as putting share folders, e-books, question banks, lecture-notes, Gantt Charts, etc., on institute website have been used or sent by e-mails to students (but to a limited extent) so that classroom/lab sessions turn to be more interactive/involving and brainstorming, yielding improved examination results by 20-30%, especially for the first/second year students.

Kaizen Environment and Team Building

Student's knowledge and experience is acknowledged in progressive institutes. Some universities in developed countries have recognized students' pivotal role in such functions as administration, curriculum development, management, etc. Mike considers universities as glorified high schools. He says university is meant for autonomous learners, to be weaned from the dependency and passivity of high school pedagogy and student is expected to take charge of their own education, self-reliant or independent. Why do the bells ring every hour? Why classroom Time Tables? Why all days working? Little or no time for reflection, absorption or, most importantly, extended reading and research. See the classroom architecture, slightly glorified compared to high schools but hardly serves the purpose of university education. Faculty has high school mind set, thus there is still a long way to go [2, 18]. In fact, all the present and future approaches assume that every one concerned (a stakeholder) does get involved in the task with a sense of belongingness, the basic feature of TQM. To achieve this, creating environment of kaizen teams or quality circles or small group

working is essential [19]. In an institute, besides Governing Body/Board of Directors, Academic Advisory Body and Local Managing Committee (all statutory bodies), there could be as good as 30 committees from steering to students' associations. Student council having four wings -NSS, NCC, sports and cultural activities- can be effective if Kaizen team spirit is inculcated. In fact, students can contribute to a great extent in all areas of institute functioning from department library to hostel management. Where students are made responsible, the outcome is positive, may be curbing out ragging, organizing events, social gathering, lab work, collaborative learning, choice centered classroom instruction, etc. [20].

Material Management

AICTE, a statutory body, is the apex body meant for Technical and Management Education in India; regulating institutes of engineering, pharmacy, Architecture and Fine Arts, Hotel Management and Catering Technology, MBA and PGDM, MCA, etc. The economics of such institutes is of national interest/importance. 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., and equipment is over Rs 2, 07,280 crores (10, 364 institutes @ Rs 20 crores) and Rs 1, 55,460 crores (10, 364 institutes @ Rs 15 crores) respectively. For consumables, etc., the estimate is over Rs 20, 728 crores (10, 364 institutes @ Rs 2 crores) pa. All these investment of Rs 3, 83,468 crores are national assets. Some institutes are already implementing ERP but with limited success due to less integration of institute management functions like those six defined by Henry Fayol (a French mining engineer, 1841-1925), i.e., technical, commercial, financial, security, accounting and managerial. Especially, dead stocks like computers, machines, test-rigs, instruments, furniture, etc., and consumables such as raw materials, tools, stationary, bulbs/ tubes, lubricants, etc., need special attention. Stray attempts are reported but not applied scientifically on institute-wide scale [21]. Effective planning and implementation of such activities as timely selection of equipment, foolproof purchase orders and inspection, effective negotiations, cash discount, etc., can reduce the material costs by 10-15%. For example with effective negotiations the housekeeping contract is bagged at 88.70 % of the bidding costs of Rs 2.82 lakhs pm, excluding service and other taxes 13%.

Single Minute Exchange of Dies (SMED) / Quick Change Over

New students entering into institute every year and students entering in to subsequent higher terms need new set up every time, like setting roll numbers, faculty loading, lab-purchases and maintenance, etc. Judicious identification of internal and external activities of set up can help reduce set up time. In fact, set up time expands in institute due to conversion of internal activities into external activities, contrary to the principle of SMED. This so happens by virtue of late display of timetables, staff on vacation, late admissions, late result declaration, etc. Delayed change over in place of quick change over, is one of the major causes responsible for deteriorating quality of education. SMED approach is the right medicine to do away with this ailment. As a matter fact, SMED can be effectively used during vacation period that was 90 days pa earlier now it is 70 days p.a. Even in case of trivial activities like scheduling batches in workshop, labs, computing center, digital library, or classrooms, alternative arrangement of faculty/staff in place of an employee(s) on long leave, deputation or maternity leave (180 days), etc., SMED is proving rewarding, saving both time and money keeping institute on schedule with no additional costs.

Engineering Economics of Institute

It is estimated (on lower side) as stated earlier that the Technical and Management

tertiary education sector has created the national assets to the tune of Rs 3, 83,468 crores, direct employment: faculty: 1, 30,299 (19, 54, 482/ 15), Staff: 1, 62,874 (1.25 * Faculty No.) and indirect employment above 5 lakhs. Table 3 presents engineering economics of an engineering undergraduate institute. The assumptions are:

i. Student-intake: 300 pa (5 programmes each of 60 intake).

ii. Duration of programme: 4 years.

iii. Total student's strength: 1200 pa.

iv. Faculty (1 teacher per 15 students): 80 (including Principal/Director).

v. Faculty average salary: Rs 5 lakhs pa/ faculty (6th Pay-scale).

vi. Staff (staff/faculty=1.25): 100 staff (non-teaching, including technical/ministerial, etc).

vii. Staff average salary: Rs 2.5 lakhs pa/staff (6th Pay-scale).

viii. Tuition fees: Rs 70000 pa/student.

ix. Revenue from Hostels and other sources like interests on FD, sponsorship, etc., not considered.

x. Depreciation, rent on building, etc., excluded from expenses.

The rapidly rising tuition fees, that is fixed by the State Fees Committee based on institute's audited balance sheet (i.e., cost based approach) has started irritating the masses for greater access, equity and reduction in fees (i.e., cost reduction) is a call of the hour. This can be achieved by cost reduction in institute, namely, deploy IE approaches like Value Engineering/Analysis and others to some vital cost centers of institute [22]. Some States in India like Madhya Pradesh, have adopted a policy of uniform fees throughout the State that

Revenue	Rs Crore
Tuition and other fees (1200 students*Rs 70000 pa)	8.4
Consultancy, etc.	0.2
Grand Total	8.6

Utilities & services	Rs Crores
Energy	0.12
Water	0.1
Bldg maintenance	0.1
Others (legal, etc.)	0.08
SubTotal	0.4

Expenses	Rs Crores
Salary faculty (80* Rs 5 lakhs pa)	4
Salary staff (100*Rs 2.5 lakhs pa)	2.5
Development (Library, new equipment)	1
Utilities & services	0.4
Consumables	0.5
Sundry expenses	0.3
Total Expenses	8.7
Surplus/Deficit	-0.1
Grand Total	8.6

Table 3 : Engineering economics of an engineering UG institute, 300 intake, 5 programmes

appears to be logical, as AICTE has specified the minimum requirements in terms of manpower, infrastructure, etc., assuring quality of education. In fact, fees can be cut down drastically if institute deploys judiciously the cost reduction tools and techniques with due regards to quality. This can be further reduced if state (that collects education cess 3% on IT and other taxes like service tax)/public support financially to some extent to institute. Human capital is the future treasure for a country underscoring the responsibility of state/public.

Standardization

Days in and days out institute's over 90 % activities remain almost non-variable, and some are highly repetitive in such areas as (1) students related- admissions, roll number assignments, ID card issue, issue of Leaving/Bonafide Certificate, etc., (2) employee related – payment of salary, leave sanction, teaching load distribution, department teaching load, number of employees, footage for seating etc., (3) university/AICTE/State related- yearly approval, increase in intake, examinations, etc. For instance, generate a computer based single ID number for students, like an Opitz GT code for every component coming in that can be used for all purposes in later years by institute and university. Such and similar modes of standardization can be uniformly used by institute and regulatory bodies as well saving both money and time.

Information network

Physical and organizational networks can be effectively operated and managed provided one has an effective information network. Internet, face book, skype, twitter, social community groups, cloud computing can fruitfully be applied to create a sound information network, intra-and-inter and outside world [23]. Besides such networks at institute level, state has to bring in national network in the matter through agencies like NKC. AICTE the apex body has to play a key role in such development so that in a real sense India can deploy BNM and VIBE all over the country including AICTE itself [24].

The potential benefits of IE approaches in tertiary education

Some potential benefits that IE approaches can fetch to tertiary education sector can be summarized as given below:

1. Reduction in material cost by 10-30%.
2. Reduction in lead-time by 20-30%, facilitating say conversion of four years degree course in three years, thereby saving one year of youth power of the country.
3. Reduced manpower requirements by 20-30%, downsizing and tenure based employment with higher compensation performance linked.
4. Standardization of formats (including for Seminar and Projects), procedures, records, material and methods, etc., saving in terms of time and money to the tune 15-20%.
5. Ease of control and administration.
6. Quality service to all stakeholders.
7. Quality education at reduced costs with effective delivery on time (e.g., on time examinations, results, admissions, starts and ends of terms, etc).
8. Cost of education can dwindle down by 25-30%,
9. The students will be living and experiencing the real-life environment of industry in institutes itself, the greatest advantage, improving their employability, personality and generic skills.
10. Enthusiastic and self-motivated employees and students, creating brand and high moral.

Scope for future work

There are several areas of institute functioning that are eagerly waiting for further improvement. Cost reduction is the immediate need. Other significant areas can be kaizen team building, process and performance management, standardization in documentations, processes, materials, target setting, performance appraisal, performance-linked-compensation, reduction in degree duration say from 4 to 3 years, etc. Application of IE tools to such areas can play a key role enabling India to be a superpower.

Conclusions

This paper emphasizes that education and training of man, are essential ingredients for country's socio-economic development. Education sector is nothing but a service sector. The approaches as being used/and experimented in industry world are advocated for jidicious implementation in education sector, especially the tertiary level. Models like Business Navigator Method, Virtual Interactive Business Environment and Process and Performance Management are considered for education sector and IE approaches/tools are applied to this sector for continuously improving efficiency, effectiveness, and economics of education pulling one and all towards education and training, providing them quality education at lower cost with on time effective delivery. A few areas like classroom/lab teaching, administration procedures, MRP, SMED, JIT, PDCA, standardization, Kaizen, etc., are discussed but briefly. The paper identifies the potential areas of institute functioning for deploying IE approaches and expected outcomes are also brought out. It is believed that this paper will be of interest to all stakeholders.

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