7. ENGINEERING APPROACH TO ENGINEERING EDUCATION

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Abstract

Engineering education, among all higher education in India, has been most progressive. Curriculum reforms, examination and assessment reforms, industry linkage, use of ICT in admission and education delivery have been introduced to a lesser or greater extent across engineering institutions in the country. Similar thrust is not observed when it comes to administrative and fiscal reforms. In a typical institution, the two, academics and administration, merely coexist as two independent cultures.

The paper argues that quality of an engineering institution or any educational institution for that matter, would improve if innovation in academics occurs in tandem with innovation in administration in fact, the full import of innovation is possible only when the two, academics and administration, are integrated as in an engineering systems design. Evidently, the systems approach of engineering design has not been applied to designing an engineering education institution. While stressing a need for such an approach the paper presents a worked out example of a set of innovations in academics and in administration, shows the nature of integral relationship between the two and brings out how integration helps improve quality of education

Paper urges the readers to ponder over the following beliefs

i) Academic reform can be done without administrative reform

ii) Faculty should not be involved in administration

iii) Reform is not be possible without additional funds

iv) Innovation can be externally grafted

v) Norms are externally determined and uniform for all

Engineering approach to engineering education is needed to improve the quality of engineering education.

Engineering education, among all higher education In India, has been most progressive. The reasons may be many, but one of them is certainly the role played by AICTE (All India Council for Technical Education) since its inception in 1945. Under the leadership of AICTE and because of the presence of IITs as role models for engineering institutions, engineering education has been far more adaptive and responsive to new demands. Curriculum reform, examination and assessment reform, industry linkage, quality improvement program for faculty use of ICT In admission and education delivery have been Introduced to a lesser or greater extent across engineering institutions in the country.

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1. NATURE OF REFORM IN ENGINEERING EDUCATION

If one took a bird's eye-view of all reforms in engineering education across the board, following broad observations emerge:

- Reform has normally been externally induced, by the agency of the government
- Reform is normally accompanied with additional external funding from the government
- Reform has been standardized, leading to prototypes. for example, model curriculum, model organization structure, sandwich program, etc. and consequent standardization of all norms
- Much less experimentation and innovation have been reported in the areas of
  - Organizational structure and academic administration
  - New forms of decision making structures and information flows, functional view of departments and faculties to lead to new type of organization structure
  - Changes in financial management and resource optimization and generation Changes in faculty and staff management, Including recruitment and appraisal
- Each reform has been done in isolation, one at a time as a stand-alone item

It is interesting to observe that the very approach of engineering characterized by systems approach to problem solving has rarely been applied to design of an engineering education institution.

2. NEED FOR ENGINEERING APPROACH TO ENGINEERING EDUCATION

This paper argues that each engineering institution, as a self-adaptive, goal-seeking open system, must internally evolve its own integrated network of innovations, encompassing academics and academic administration in order to maximize its stated goals. The stated goals could be to improve quality of intake, or to improve market acceptance of graduates, or to achieve financial self-sufficiency, or to compete with the best institutions in the country or the world or to attract the best of faculty, or to achieve excellence in research or to achieve some or all of the above objectives.

With the help of following worked out example of a set of representative innovations, the paper illustrates the value of integrating Innovations in academics and in academic administration so as to achieve the above stated goals.

3. AN EXAMPLE OF A NETWORK OF INNOVATIONS IN AN ENGINEERING INSTITUTION

- In this example, a representative set of innovations in academic design & operations and in organization and administration have been selected
- Innovations in Academic design & Operations have been broadly characterized in terms of five main categories, namely, Academic structure, Curriculum & pedagogy, Examinations & assessment, Academic operations and Academic regulations (Table A). There are 27 innovations under the above five categories.
- Innovations in Organization and Administration have been broadly characterized in terms of six main categories, namely, organization structure, Faculty, Resources, Finance, Market development & feedback and Value addition to stake-holders (Table B) There are 24 innovations under the above six categories.
- Thus, the example has considered 51 innovations covering 11 areas under academics and academic administration.
- The integration between innovations has been shown in three Tables. Table A shows the integration between five categories of innovations in Academic design and

Table A: Innovation in academic designs & operations in an engineering institute

I Academic Structure	II Curriculum & Pedagogy	III examinations & Assessment	IV Academic Operations	V Academic Regulations
1. Composite structure of diverse program offerings	8. Modular, credit based curriculum	15. Internal, continuous	21. Admissions twice a year	26. Student empowered to make decisions *re:* courses, Industry practice, Practice project, course time table, etc.
2. Integrated Masters/Doctoral programs	9. Common core of science-based courses constituting about 50% credits across all programs	16. Relative grading	22. Course-wise registration before every semester	27. Flexibilities acceleration, deceleration, program transfer, admission with adv., Standing, marginal deficiency, free elective courses, etc.
3. Dual degree	10. About 15% of credits under elective category	17. No 'Fail' grade	23. Three times registeration in an academic year	
4. Employer-involved collaborative Masters and Doctoral programs	11. One full semester and sumer term for Industry practice constituting about 15% of credits	18. Provision for make-up examination	24. Admission to Bachelors degrees based on 'normalization' of Board marks	
5. Industry practice an integral component across all programs	12. Industry view of curriculum	19. Course-wise promotion	25. All operations integrated and computerized	
6. Multiple entry points to a program	13. Unstructured courses	20. Multiple parameter evaluation in Industry practice		
7. Semester system	14. On-line course material			

Table B: Innovations in organization and administration in an engineering Institution

I Organization Stucture	II Faculty	III Resources	IV Finance	V Market Development & Feedback	VI Value addition to Stake-holders
a. Functional, structure and not faculty/ department based	g. Flexible recruitment	k. Centralized deployment of all resources e.g. faculty, classrooms. Labs, library, etc.	n. Uniform fee structure across all programs	r. Organic linkage with industry for continuous year feedback	u. Opportunity to students for indivudualization of curriculum
b. Managed by academic administrators	h. appraisal centralized. Insitutition-wide	l. Computerized monitoring of resource utilization	o. endowment fund built from savings	s. Converting employer from end-user to customer	v. Opportunity to students of industry experience
c. Faculty involvement in adminstration	i. 360 degree appraisal	m. Access to industry resources	p. Savings by leveraging industry resources	t. Addressing new student segments	w. Industry ready entry level professions is
d. Integrated computerized MIS	j. Participation in Industry practice		q. Saving by way of integration in academic & administrative structure		x. Staff development opportunity for industry
e. Institutional research					
f. Students participation in administration (as Registration Advisors, in Academic Counseling, in managing Industry practice, etc.					

Operations. Table B shows integration between six categories of innovations in Organization and administration. Table C shows integration between innovations in Academics and operation and Organization and administration.

4. ELABORATION BY EXAMPLES

Industry Practice:

Let us say that one of the goals of an institution is to have industry seek out its graduates in the employment market, irrespective of their discipline and degree. To achieve this goal, institution introduces an off-campus Industry practice as an integral curricular component of all the undergraduate programs. However, this innovation, in isolation, would have limited or no impact unless there is an adequate educational preparation of students preceding Industry practice. Real-life problems in the world of work require exposure to many

knowledge disciplines than a specialization in a single discipline. Hence, the introduction of broad-based science-intensive, common core courses becomes a necessity. This would mean that all students, irrespective of the program, undergo a common package of core courses in each of the basic disciplines constituting about 50% of credits of the degree program. This results in reducing the so called service courses and thereby, in removing duplication of course offerings by various departments a familiar practice in many universities. Further, in order to make space for Industry practice, the number of campus based courses in a degree program is reduced. Introduction of Industry practice leads an institution to another reform in education pedagogy, examination and assessment. The evaluation in the industry practice component can not replicate the evaluation in a class-room based course. Further, it provides a unique opportunity to innovate on multiple parameter evaluation in which parameters are what Industry values, viz problem solving ability, ability to meet deadlines, team-work, ability to work under real time pressure, communication skills, etc. Thus, a single goal of making graduates readily acceptable by industry, leads to a series of interconnected curricular, pedagogical, examination and evaluation reforms. And, importantly, as an institution builds an organic linkage with Industry through Industry practice, it starts getting an authentic feedback round the year. This feedback itself generates an opportunity for innovations in terms of new programs, new courses, and new teaching methodologies; and so on. It does not stop there. in turn, it requires a series of organizational and administrative changes, as described below, which have to go hand in glove.

Effective implementation of industry practice would require whole-hearted participation of faculty, with presence at industry The entire HR policies vis-à-vis faculty from recruitment to reward system needs a re-look. Effective participation in Industry practice need be considered as a vital parameter for promotion. Needless to say, this entails development of efficient management information system, which can give continuous feedback from the field (industry).

Managing Industry practice round the year for all students with faculty presence at off campus industry locations would indeed need a dedicated administrative unit. It would only be a wise economical decision not to managedepartmentally.

The spin off from a single innovation of industry practice is far-reaching. It enables access to industry resources, hitherto unavailable it enables saving of campus resources, not only because the students are not on campus for one full semester but also because of reduction of campus courses. This in turn, permits the institution to proportionately Increase the enrolment and thereby increase earnings from fees. Introduction of industry practice with all associated innovations, enables the institution to position all program offerings at par and be in a position to charge uniform fees structure. Ability of an institution to draw better quality students improves manifold

The above example of industry practice amply reveals the integrated nature of innovations and establishes that an engineering approach to planning and implementing of good educational ideas delivers cost-effective quality education.

Functional organization structure:

Let us take another example of how an institution goes about achieving the twin goal of complete financial self-sufficiency and improving market acceptance of its graduates.

The prevailing pattern of organization structure is that an institution is divided into largely autonomous faculties or departments while admissions and examinations, planning and administration are handled centrally by the staff of Registry. This type of structure does not make cost-effective use of resources, as each faculty/ department functions independently resulting in duplication of similar resource in a

non-integrated manner.

A unified organization structure is an innovation in which faculties or departments are only logical entities and not physical entities. The basic entities of the organization are formed around core educational functions viz. admissions, academic registration & counseling, academic instruction, research & consultancy, Industry linkage, educational development, educational hardware, etc. Each entity or unit discharges its function encompassing all the programs viz. Academic instruction unit is responsible for academic offering of courses, teaching allotment of courses to faculty, semester timetable of courses, academic monitoring of course operation, etc. Course registration in each semester for all students and monitoring of student progression as per academic regulations of the institution is the responsibility of the registration and counseling unit. Similarly, organization of industry practice and educational responsibility of conduct of industry practice for students across all programs of the institution is the responsibility of the industry linkage unit.

The above organizational structure supports Integration of academics viz. all programs integrated into a composite structure with interrelationship between them defined through academic regulations; uniform academic regulations for all programs, unification of all undergraduate programs through a common admission process and common courses In the first two years; for students, seamless access to courses, dual degree; program transfer; interdisciplinary problem solving exposure to students during Industry practice, etc In fact, reform in organization structure can be seen to be vital for deriving the full benefit from an academic reform.

The above described organizational and academic Integration is a significant step towards achieving financial self-sufficiency as it enables financial savings in the operative expenses by way of:

- Full integration of physical and human resources
- High utilization factor of all physical resources viz. classrooms, laboratories, equipments, library
- Minimization of waste or redundancy

Unified automated information system:

Efficient operation of integrated system, totally focused on improving quality of education and financial self-sufficiency, would not be possible without automated information system. Time--bound operation of all processes from admission to certification, maintaining student data, which could supply instantaneous information about the individualized academic path followed by a student within the large degree of flexibility permitted to him; institutional research through continuous scientific analysis of student performance, courses, feedback from industry, resource utilization; staff data and budget and finance monitoring would need a unified automated information system it would bring in the accountability and transparency in the system and also act as a catalyst for continued innovation.

5. ENGINEERING APPROACH FOR QUALITY ENGINEERING EDUCATION

From the above example of a set of innovations and their elaboration it is clear that full impact of innovation is possible if systems approach of engineering design is applied to designing an engineering institution. Clarity on institutional goals, on resource availability and constraints is important. Innovation in academics must be supported by corresponding innovation in administration. Network of integrated and interdependent innovations is the key to improving quality of engineering education.

The above example clearly reveals the following nature of innovation in an institution

- Innovation is not a one time isolated phenomenon. One innovation simultaneously

demands more innovations in all related areas or activities Thus, it is always a network of innovations with a holistic goal. It is also not a one time change, but a continuous process.

- If an institution must perpetually innovate, the nature of its administration is of scientific problem solving, requiring continuous real time analysis of performance of system. Faculty participation in administration is a natural corollary.
- In a systems approach, innovation helps saving and generating resources rather than consuming them. It is worth pondering over a general belief that reform needs additional funds.
- It is worth pondering whether innovation can be externally grafted. The idea may be drawn externally, but engineering details of the idea have to be specific to institution. Hence the design and its implementation have to be internally evolved in a continuous process.
- It is equally worth pondering whether the norms for impartation of quality education should be uniform and fixed for all at all times.
- Innovation, to be successful, must include all stake holders. students, faculty, industry as end-user and society at large.

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