CURRICULUM DESIGN OF MECHANICAL ENGINEERING IN A DEVELOPING COUNTRY

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Abstract: The curriculum and syllabi in Engineering Education is dynamic as it shifts with societal requirements as well as student inputs. The present paper deals with a study of the historical data of the changes in basic components of mechanical engineering curriculum in a developing country - the case study being that of Mechanical Engineering Department, Jadavpur University for last 50 years. Jadavpur University is presently ranked amongst the top 6 science and engineering institutes in India with respect to research ranking (based on Scopus data) or accreditation agency ranking (institution based). The study shows, that lack of local industrial input has been a predominant feature in changing the percentage of basic components in engineering curriculum and needs to be addressed even though technology is considered to be borderless now.

In the GATS regime, homogenization of engineering education is being attempted through Washington Accord, Bologna treaty etc. India is a signatory to the Washington Accord. Accordingly, AICTE, which is implementing this in India have formulated a curricular framework which includes 10-15% Basic Sciences, 15-17.5% Engineering Sciences, 10-15% Humanities social sciences and Management, Professional core 22.5-27.5%, Electives 19.5-25%, Seminar and Industrial Training 2.5-5% and Project 5-12.5%. However, author is of the opinion that even with cross-border movement of engineers, the national requirements should get priority in framing curriculum and syllabi of that country, which this work highlights with respect to one of top universities and research institutions of India, Jadavpur University. Such studies can give an insight into academic ranking and strength of the same department in various institutes.

Keywords: Curriculum Design, Engineering, Developing Country

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1. INTRODUCTION

Curriculum is the formal mechanism through which intended educational aims are achieved. This formal mechanism includes two prime factors: learning and instruction. The curriculum incorporates the social, cultural and even political background of the programme of a course. It is

defined by a set of subjects taught in a particular course with hierarchical structure (linked), duration (periods and credits), % of theory and practical in overall course structure, evaluation procedure and standards. Curriculum issues are inseparably linked to current thinking and action on educational concerns and reforms around the world. Syllabus forms the core of curriculum. They are the components of the curriculum.

2. CURRICULUM DEVELOPMENT

Curriculum development is the systematic process of designing and preparing all the courses offered in a particular subject. It is one of pedagogical exercises that are necessary for development of education. Its development requires a broader view that considers the needs and the impacts of students, teachers, institutions, employers and governments and includes the factors like content, teaching and evaluation strategies, teaching resources and facilities. Curricula may be organised at two levels. The first approach (Heywood, 2005) may be at a macro level, in which the decisions are made about the type of courses to be offered, the amount of time to be devoted to each, the way they will be arranged over the program and so forth. Second, the particular content elements and learning activities can be selected and organized to optimize the knowledge gained by the student. This later approach usually deals with materials within the courses and can be based on principles of teaching and learning and of curriculum design. The two types of organization may be compared to the adjustment as in tuning a mechanism or an instrument; first gross adjustments are made, and then fine tuning is carried out based on group requirements.

The design of the entire curriculum process is intended to illustrate the syllabus as being the outcome of a complex design activity. This involves the declaration of objectives and simultaneous design of assessment and instruction procedures that will cause those objectives to be obtained for a particular programme and institute.

As a discipline of engineering, Mechanical Engineering is not very old. Its relevance became more important with Industrial Revolution and ultimately manufacturing & power production led to its growth (Burstall, 1965).

3. GROWTH OF JADAVPUR UNIVERSITY: CASE STUDY FOR A DEVELOPING COUNTRY

In India, the desire for creation of centres of technical training came from the British rulers and it arose out of the necessity for the training of overseers for construction and maintenance of public buildings, roads, canals, and ports, and also for the training of artisans and craftsmen for the use of instruments, and apparatus needed for the army, the navy, and the survey department, in particular.

In India the colonial model of technical education with the establishment of Guindy College, Chennai (1794), Thomason College, Roorkee (1847), Poona Engineering College (1856), Civil Engineering College, Calcutta (1856) and Victoria Jubilee Technical Institution, Bombay (1887)

went in one direction. The curriculum and the training in these colleges were geared mostly to meet the requirements of only subordinate grades of engineering services of the then British colony, India. However, a national model different from colonial model was attempted to be developed in Calcutta with the establishment of National Council of Education, Bengal and the Bengal National College & School in 1906.

Its main aim was to provide education - literary, scientific and technical 'on national lines and under national control' (Sarkar, 1946). The institution had four departments – Literary, Scientific, Technical and Commercial. The teaching section of the Technical Department imparted both theoretical and practical courses. The students had to attend laboratory work and workshop training along with classroom lectures. Thus practical handling, shaping, breaking, analyzing & measuring of materials was an important part of the training imparted in the Technical Department of the National College. Right from the beginning, the Bengal National College displayed this "three dimensional" system of education combining teaching with factory work. Other subjects taught included: Drawing – freehand & mechanical, Physics, Chemistry and Mathematics. The technical department had also a manufacturing section which did some industrial works for other business firms (Mukherjee, 1909).

For the promotion of technical education alone, in the same year, a second organisation, rival to the National Council of Education, named Society for Promotion of Technical Education (S.P.T.E.) was established and this later founded the Bengal Technical Institute (BTI), the first nationalist technical school in India. In BTI, two courses were offered: primary courses which include practical training in Mechanical fitting, electrical fitting, carpentry, drawing and surveying. And the secondary courses included Mechanical Engineering, Electrical Engineering, Dyeing & Bleaching, Industrial Chemistry and Economic Geology & Mineralogy. BTI also had a manufacturing department (Sarkar, 1946). On 25th May, 1910, the Society for Promotion of Technical Education and the National Council merged and formed the Central National Institution. Later it was renamed as the College of Engineering and Technology (CET) in 1929.

Time progressed and on 24th December, 1955, Jadavpur University was formally established with Dr. Triguna Sen as the Rector (equivalent to Vice Chancellor). As a reincarnation of the CET, Jadavpur University continued to abide by the noble ideals and aspirations of the National Council of Education, Bengal and created 3 separate faculties of broad disciplines in international line – Arts, Science and Engineering. Throughout its first decade the University continued to add new departments and new subjects in the curriculum with due regard to the industrial requirements of a growing nation.

3.1. History of institutional changes in curriculum at Jadavpur University: analysis

The present study shows that the curriculum for Mechanical Engineering courses at Jadavpur University has undergone a continuous change over a period of 50 years, because of the perceived notion of changes in curriculum framework imposed by the faculty as well as the regulatory body All India Council for Technical Education (AICTE) in the later years. As per standard procedure, the curriculum framework has been divided into some areas namely Basic Sciences, Humanities, Social Sciences and Management, Engineering Sciences, Professional Core Subjects, Electives, Technical Arts/Drawings, Workshops and Laboratories. Data on total

periods allotted have been taken for the years 1966, '74, '86, '99 and 2009 and a percentage has been calculated (Table 1).

	Year 1966	Year 1974	Year 1986	Year 1999	Year 2009
	(%)	(%)	(%)	(%)	(%)
Basic Sciences	17.65	15.93	8.5	9.58	8.82
Humanities, Social Sc, Management	7.45	6.97	5.67	5.34	5.88
Engineering Sciences	18.72	13.69	24.19	22.69	25
Professional Core Subjects	10.16	15.43	17	19.35	21.32
Electives	2.14	1.99	2.83	4	4.41
Technical Arts/ Drawings	18.98	17.67	15.59	14.68	11.03
Workshops	12.03	11.63	11.37	11.01	9.19
Laboratories	12.83	16.68	14.88	13.34	14.34

Table 1: Percentage Values of the curriculum framework based on the periods allotted over the last 50 years for the Mechanical Engineering Department

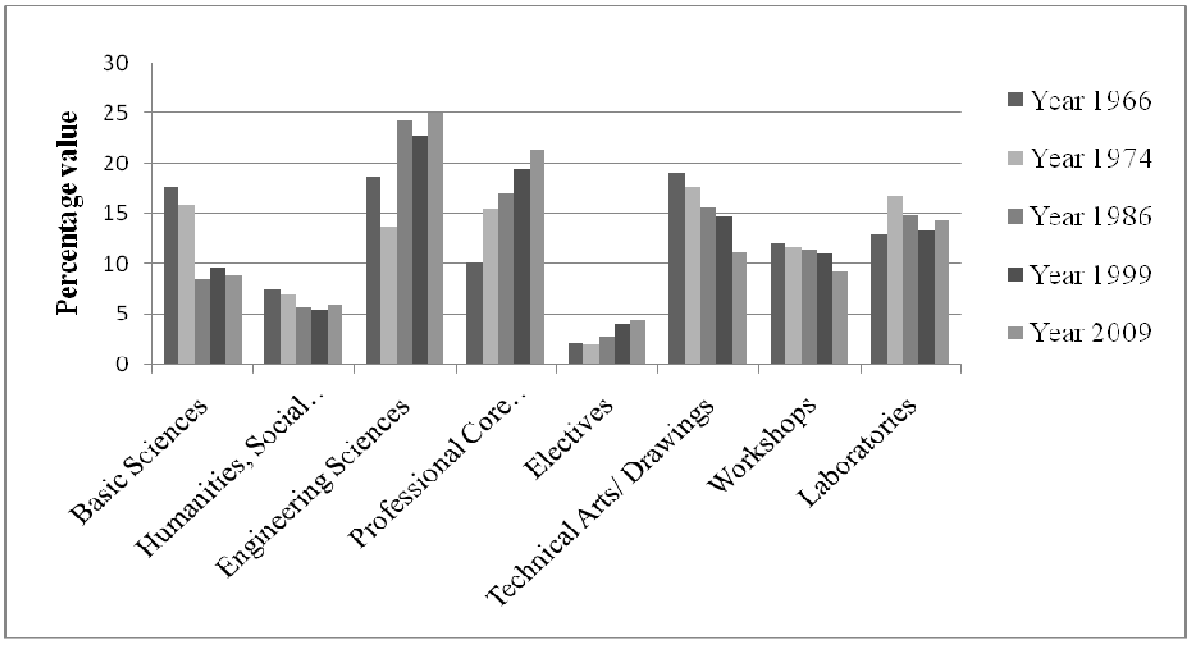

Figure 1: Variation in the areas from the year 1966-2009 in the Mechanical Engineering curriculum at Jadavpur University

A comparative analysis of the changing trends in the Mechanical Engineering curriculum has been shown in Figure 1 (Based on percentage values of periods allotted in Table 1). The analysis based on the cumulative calculations leads us to following conclusions regarding distribution of curriculum framework.

3.1.1 Distributions of Basic sciences

Basic sciences are responsible for generating fundamental thinking ability in students. An analysis of the percentage of basic sciences over the years shows a steep decline from the year 1986 onwards. This remarkable drop of about 8.83 % is indicative of the fact that during the early 1970s the courses were based on a five year duration which led to the introduction of calculus based science subjects like physics, chemistry as well as mathematics to a much deeper extent than what they are in a present four year curriculum. The integration of school and degree level engineering curricula needs a thorough study.

3.1.2 Distributions of Engineering Science

The percentage of Engineering Science has not undergone drastic changes (Table 1). This shows the trend has been towards increasing the percentage of engineering sciences in curriculum framework in order to instil in student's mind a sound pedagogic system which aims at providing the students with a clear concepts of engineering at the beginning of the learning stage itself and strengthen their foundation to enhance their capability of understanding when they deal with professional core subjects and electives.

3.1.3 Distributions of Social skills

The percentage of Social skills (humanities, social sc. & management) had decreased by 2.11 % till the late 1990s from 7.455 in 1966 to 5.67 in 1986, but tends to show a gradual increase in the recent years from 5.34% in 1999 to 5.88 % in 2009 (Table 1). World over, all the accrediting agencies are talking about the need of engineers having more communication skills, knowledge of economics, ideas of professional ethics etc. So, all the latest guidelines including ABET, Bologna or India's AICTE suggest percentage increase in social skill courses. To incorporate this, some sacrifice may have to be made at other areas and that is yet to be agreed upon unanimously. However, if we look at Jadavpur, it seems that the contribution to society by engineers can be increased with more emphasis on social skill in curriculum framework.

3.1.4 Distributions of Professional Core subjects

The numbers of periods allotted to Professional Core subjects have witnessed a steady increase over the past 60 years as depicted by the bar charts (Figure 1). The percentage of periods allotted to this field was 10.16 % in the curriculum framed for the year 1966, and has increased steadily to 21.32 % in the year 2009 (Table 1). This significant increase has been necessitated due to developments in the field of Mechanical Engineering into newer areas of energy, manufacturing and interdisciplinary areas as robotics, biomechanics etc. Also, as is traditional in Jadavpur University more stress has been put on fluid machinery, manufacturing technology and advanced computational techniques such as Finite Element Methods. These changes match the industrial needs as placements of alumni has shown. But this increase has been done at the cost of technical arts/ engineering drawing, workshop classes. Traditionally these were strong points of Jadavpur University (AICTE India, 2007).

3.1.5 Distributions of Electives

The percentage of Elective period allocation has seen a steady rise from 2.14 % in 1966 by 2.27 % to 4.41 % in 2009 (Table 1). This can be related to the point raised in the earlier conclusion that the students need to have core knowledge of the discipline. The specialized areas can be covered by electives (optional) which can be chosen by the student depending on his/her aptitude, as well as the requirement at that point of time of the industry. It must be clearly noted here that the need of industry varies with time. For outsourcing of some of the countries of software management, there was a requirement of engineering graduates. But with the development of climate change issues and the thrust on biomedical solutions, the number of electives have been increased as some of the following names suggest—solar energy, aerodynamics, computer aided design and manufacturing, biomechanics and biomaterials, advanced dynamics and vibration, design of thermal systems etc.

3.1.6 Distributions of Technical Arts/Drawings

The contribution of Technical Arts/Drawings to the curriculum framework was 18.98 % as obtained from the 1966 period allotment. But this has seen a remarkable drop since then and has decreased to just 11.03 % in 2009 resulting in a decrease of 7.95 % (Table 1). This shows less emphasis on hands on drawings over the period of time. The reason might be the perceived notion of lesser employment of students in consultancy organizations and advent of computerised drawing. The effect is yet to be observed because many of the engineering subjects particularly engineering mechanics needs a very good conceptual understanding of the physical system which needs good concept of technical arts/drawings.

3.1.7 Distributions of Workshops

The percentage of Workshops held during 1966 has dropped down steadily from 12.03 % to 9.19 % in the year 2009, a decrease of 2.84 % (Table 1 and Figure 1). This strengthens the report which says 75% of engineers in India are unemployable and they have cited the reason as more thrust on academics and theory (The Sunday Statesman, 2009*)*. Engineering (or for that matter Technology) relates to practical applications. So there is a contradiction here that needs to be resolved even keeping in mind that the growth of the Mechanical Engineering discipline has been explosive.

4. CONCLUSIONS

The imposition of General Agreement on Trade in Services (GATS) regime in education sector necessitates enrichment and broadening of engineering curricula so that engineers will be better prepared to work in a changing global economy from now. The curriculum design has become a central paradigm in engineering education. Accords & treaties like Washington & Bologna etc. have been agreed upon to homogenize curriculum. Accordingly, AICTE, which is implementing this in India have formulated a curricular framework which includes 10-15% Basic Sciences, 15-17.5% Engineering Sciences, 10-15% Humanities social sciences and Management, Professional core 22.5-27.5%, Electives 19.5-25%, Seminar and industrial training 2.5-5% and Project 5-12.5%. However, author is of the opinion that even with cross-border movement of engineers, the national requirements should get priority in framing curriculum and syllabi of that country.

Novel curriculum design and introduction of innovative courses go a long-way in moulding the career of younger students into various walks of life in the society. In this respect, Jadavpur University has made great strides in designing their curricula. Considerable freedom and flexibility for the faculty to design relevant and innovative courses have earned a good reputation for the University. The institution has travelled a long way from a College of Engineering & Technology to Jadavpur University and successfully established itself as one of the better Indian research and teaching institution with a vast repertoire of courses offered.

Development of Indian technical education has been mainly on two models: colonial and nationalist. This particular institute taken for case study developed on a nationalist line (Sangwan, 1990). For a country, which is still categorised 'developing', emphasis has been more on hands on training, design & drawing and to some extent motivation of entrepreneurial skill (Khanduja et al., 2009). Small & medium industries development has been a thrust area of most Indian institutes' curriculum excepting Indian Institute of Technology (IITs) (Arakeri, 2006). That is reflected in the analysis.

Industrial feedback is a must for any curriculum framework that is absent in most of the educational institutions in India as well as in Jadavpur University. This has to be rectified. It can be reported here that in the Technical Education Quality Improvement Programme of the World Bank at Jadavpur University was allocated the task of spending a portion of the grant for services to community and economy which has been suggested to be included in curriculum framework at later stages (Saha, 2007). This is very important for developing countries which need to be addressed in similar studies.

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