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Performance under Varied Management Styles – a Comparative Assessment of Engineering Education Programmes in India

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Abstract

This paper compares the performance of engineering education programmes in India under varied management styles. The comparison is based on the scores allotted to various engineering programmes by the expert teams of National Board of Accreditation, India. The study has been formulated on the statistical techniques of hypothesis testing and multiple comparisons on the performance scores of 160 programmes from various states of India. It is found out that the performances of Autonomous colleges are superior and autonomy helps in the improvement of process factors of the engineering programmes, especially for the Industry-Institute interaction and R&D activities.

Keywords: Performance comparison, Engineering programmes in India, Management styles of engineering programmes, Autonomous programmes

1. Introduction

The last three decades witnessed a lot of changes in industrial and educational fields. With rapid progress in the information and communication technologies, the demand for technical manpower in this area has also increased. This has resulted in setting up of a large number of institutions through out India, offering a variety of programmes to meet this demand. In terms of the magnitude of human resources, expertise available and of physical facilities created over the last three decades, the system of technical education of India has become a formidable reservoir of technical expertise in the global scenario.

The new economic policy regards expenditure on higher education as less of an investment of the nation in the future and more of a subsidy to a relatively affluent section of society. Many universities are currently facing the challenges of reorienting their approaches to be more customer-focused and conducting their activities in a more business-like manner (Hides et al., 2004). The adoption of a market-oriented approach in running education is said to have the consequences of adoption of the fee-paying principle and popularity of revenue generation activities (Mok, 2000). In order to reduce the burden on the government in educational provision, in many countries, public administrators consider economic factors the most important ones, and most of the time it is the economic considerations that drive individuals and shape social and public policy (Mok and Wat, 1998). The demand on technical institutions to sustain on their own without grant/support from the government has also increased. These changes have created a need for private resources and a new species of 'businessmen as providers of technical education' has emerged (Padmanabhan, 1999). Due to these policy reasons most of the new engineering colleges in India in the last decade started in private sector working under self-financing basis (AICTE, nd). The spontaneous growth in engineering education sector with a nominal control of Government has led to many quality problems. Some of these problems are inadequate supply of well qualified experienced faculty, too many colleges affiliated to a single university, location of many institutions far away from industry centers and lack of understanding between the Government & managements of self-financing institutions on the fee structure & admission processes. An analysis of performance of these institutions is of great significance in this situation and could help us identify some policy options to improve the quality of education.

2. Management of engineering institutes

Institutions offering engineering programmes in India can be broadly classified into four major categories, namely Autonomous, Government, Aided, and Self-financing colleges. These colleges work under different circumstances with different working styles.

2.1 Autonomous colleges: - Indian Institute of Technologies (IIT), National Institute of Technologies (NIT) and some other high profile colleges function as autonomous institutions in India. Most of them are 'deemed universities'. They enjoy academic, administrative as well as financial autonomy.

2.2 Government colleges: - Central and State Governments administer this second category of colleges. All India Council for Technical Education (AICTE), State Governments and Universities, to which these colleges are affiliated, fix pay scales and service rules for the staff employed in these categories of institutes. University is mainly responsible for the framing of rules for the academic part of these institutes. They frame course duration, subjects to be taught, examination pattern, and the grading system. Government, based on merit as well as reservations, carries out the annual process of student admissions.

2.3 Aided colleges: - Third category of colleges is coming under grant-in-aid sector. Education societies or private bodies are managing these institutes. They take up the responsibility of providing capital assets like land, buildings, etc. Government provides salary and other working expenses to these colleges. AICTE, State Governments and Universities, to which these colleges are affiliated, fix pay scales and service rules for the faculty and staff employed in these institutes. University frames the course duration, subjects to be taught, examination pattern, and grading system. Government and Management, based on merit as well as reservations, admit students to these institutes.

2.4 Self-financing colleges: - Fourth category of colleges is working fully under self-financing basis. Education societies or private bodies which take up the responsibility of running these institutes are mainly responsible for providing physical facilities, teaching staff and other supporting staff for these programmes. University frames the rules for the academic part of these institutes. Students are admitted partly from the merit list prepared by the government and partly from a list prepared by the management.

3. Some views on quality of engineering education

According to most of the leading experts on quality, attaining quality goals through a process of continuous improvement over time depends critically upon a firm's ability to define in specific performance terms what it means by quality and then to measure these performance variables objectively (Krishnan et al, 1993). Definition of indicators of quality and the objective measurement of these indicators are critical in the assessment of quality of engineering programmes. What is quality, quality of education especially engineering education, and how it can be achieved are of great interest to the stakeholders of engineering education. Quality in education has been defined variedly - even as, "fitness for purpose" (Tang and Zairi, 1998). Some authors (Angelo and Cross, 1993; Marra et al, 2000; Murray et al, 1996; Smith and Waller, 1997) have described quality as the combination of factors like knowledge of a realistic goal, sufficient faculty-student contact hours, a balance of intellectual standards & academic support, frequent updating of courses, promotion of creative thinking, strong customer focus, importance given to collaborative learning & life-long learning and a system thinking. The concept of quality when applied to higher education has been inconclusive (Cheng and Tarn, 1997; Pounder, 1999). Education quality can be viewed as the combination of the quality of input, process, and output of the education system (Eriksen ,1995). LeBlanc and Nguyen (1997) identified curriculum, physical evidence, responsiveness and access to facilities as the factors, which explain service quality of education. To survive in the highly competitive environment, according to Kwasniewski, and Wo´znicki (1998), an engineering education programme must have the essential features of flexibility and adaptability. Many opinions can be observed in the literature about the factors influencing the quality in engineering education. Some of them are teaching process (Cropley, 2003), University – Industry collaboration (Natarajan, 2003), role of management (Gopalan, 2003), student intelligence & interest (Mouly and Padmaja, 2003), excellence of teachers (Shrivastava., 2003), accreditation standards (Prem vrat ,2003), e-education (Maji, 2003) and proper documentation of activities (Jagdeesh, 2001). While attempting to integrate ideas from TQM with a systems approach, Cheng (1996), defines education quality as the character of the set of elements in the input, process, and output of the education system that provides services that completely satisfy both internal and external strategic constituencies by meeting their explicit and implicit expectations. It is clear from the above literature review that the quality of engineering education cannot be defined by any single factor or dimension. The authors have viewed quality as the combination of various factors. The definitions of quality involve the characteristics of input, process, output and multiple constituencies of an education institution. Hence, these multi-dimensional features should be taken into account while assessing the quality of engineering programmes.

4. Framework of the study

As far as Indian engineering education system is concerned, NBA (National Board of Accreditation) accreditation process is the official performance assessment mechanism. NBA has defined criteria and standards by which the strengths and weaknesses of individual programmes in an engineering institution can be judged. This study focuses on the information based on the NBA assessment scores and visiting team reports.

A previous study based on the accreditation process of National Board of Accreditation (NBA), India, led to the development of a Process-Resource-Outcome-Management (PROM) model for the assessment of performance of

engineering programmes (Viswanadhan, 2006). This model comprises of 19 factors (quality indicators) categorized under the four groups of Processes, Resources, Outcome and Management (Table 1). This model is adopted for the present study. The comparisons are made based on the performance under the four management styles in terms of the 19 factors in the four major groups.

5. Data description

It is decided to assess the performances of engineering programmes from the score sheets prepared by the NBA expert team during their visit to the Institutes for accreditation purpose. These score sheets are confidential documents, which are not accessed by the public. Pure random sampling is difficult when dealing with such confidential data. With the special permission from the NBA, accreditation scores of 160 programmes that have undergone NBA accreditation process during the period 2000 – 2003 (from January 2004 some major changes had been made to NBA criteria) have been collected for the study. The selected samples of 160 (engineering programmes) represent the cross section of Indian engineering education system (Table 2). The programmes belong to various colleges of 13 different states of India. Different expert teams assessed the programmes. All these factors ensure the randomness of the samples.

With reference to the Table 1 and NBA score sheet, it can be noted that the 19 factors encapsulate different number of variables with different weight distributions. Hence, the normalized variable scores are found out as a first step in measuring the performance of the four categories of programmes with respect to the 19 factors for the 160 programmes. Data under each category of programmes are observed and the outliers are removed.

6. Formulation of Hypotheses

Hypotheses are formulated in an attempt to analyze the performance of varied management styles of engineering programmes (Autonomous - AU, Government - G, Aided - A and Self – financing - SF) in India.

6.1 Main Hypothesis:

'Performance of engineering programmes is the same irrespective of the management style of the college'.

6.2 Sub Hypotheses:

Sub hypotheses for the detailed comparison of programme performance with respect to different factors are listed below.

1. Equal amount of participatory management (*PM*) exists in all the four categories of engineering programmes.

2. There is no difference in leadership efficiency (*LE*) between the four categories of engineering programmes.

3. Amount of management commitment to achieve goals (*CA*) is same in all four categories of engineering programmes.

4. Planning and monitoring (*Pln*) of engineering programmes are at the same level in all the four categories.

5. Financial resources (*FR*) of engineering programmes are at the same level irrespective of the category of the college.

6. Main physical resources (*MPR*) of engineering programmes are at the same level irrespective of the category of the college.

7. Supplementary physical resources (*SPR*) of engineering programmes are at the same level irrespective of the category of the college.

8. Faculty adequacy (*FA*) is at the same level in all categories of engineering programmes.

9. Adequacy of supporting staff (*SSA*) is the same in the four categories of engineering institutes.

10. There is no difference in the Performance appraisal and development (*PAD*) system in the four categories of engineering institutes.

11. There are no differences in the student intake (*SI*) in the four categories of engineering institutes.

12. Student Performance (*StP*) is at the same level in all categories of engineering programmes.

13. Same amount of Learning Facilities (*LF*) are available in all categories of engineering programmes.

14. Instruction, Evaluation & Feedback (*IEF*) is of the same standard in the four categories of engineering institutes.

15. There are no differences in the implementation of Academic calendar (*AC*) between the four sectors of engineering institutes.

16. Equal amount of Supplementary Processes (*SP*) are there in the four categories of engineering institutes.

17. There is no difference in the institute initiatives (*II*) for industry interaction in the four categories of engineering programmes.

18. Industry Initiatives (*IyI*) for interaction with all categories of institutes are the same.

19. R&D activities (*R&D*) are at the same level in all categories of engineering programmes.

7. Testing of Hypotheses

7.1. Processing of data

As the nonconstancy of error variances and nonnormality of error terms are observed while comparing the 19 factor scores of the four categories, different techniques are adopted for cleaning the raw data. They are given below.

1. When both nonconstancy of error variances and nonnormality of error terms are observed, *Box Cox transformation + ANOVA* is used.

2. When only nonnormality of error terms are observed *Kruskal Wallis test* is used

3. When only nonconstancy of error variances is observed, *weighted least square regression + ANOVA* is used.

The details of the actions taken are also given in the Table 3.

7.2 Result of hypothesis testing

The null hypotheses are tested on all the 19 factors (transformed or raw factor scores depending on the situation). Results are summarized in Table 4.

With reference to the Table 4, ten out of the nineteen factors are different for the four categories at a significance level of 0.05. The hypotheses 5, 8, 11, 12, 14, 15,16,17,18 and 19 are rejected and hence the null hypothesis of equal performance under the four styles of management is also rejected.

8. Multiple comparison tests

Reasons for the rejection of hypotheses are not clear from the foregoing tests. A significant difference in any of the two populations will lead to the rejection of the hypothesis. Hence a detailed analysis is needed for the interpretation of the results. Multiple comparison tests have been conducted to find out the causes of rejection of the hypothesis. Wilcoxon rank sum tests are used for the non-normal data and t-tests with Hochberg multiple comparison adjustments (to control the family-wise error rate) are used for normal data. These tests are conducted for the ten factors which are significantly different for the four categories. Factors that are significantly different for the different categories of programmes are given in Tables 5. The mean values of all the nineteen factors associated with the different PROM groups for the four categories are displayed in Tables 6 to 9. Results and interpretations of the study are presented in the subsequent section.

9. Results and Interpretations

9.1 Process factors: All the Process factors are found to be significantly different under the four styles of management of the Programmes. Details are displayed in Table 5. Mean values of the process factors for the four populations are shown in Table 6.

Autonomous colleges are found to be good in almost all process factors in comparison with the other categories of programmes. Academic Calendar seemed to have been followed strictly in all categories of programmes. Instruction Evaluation and Feedback is also at good level in almost all categories. Supporting Processes like Supplementary Processes, Institute Initiatives, Industry Initiatives and Research & Development activities are at poor levels in all categories of programmes. Aided colleges and Government colleges are better in Institute Initiatives and Government colleges are getting more Industry Initiatives for interaction. Supplementary Processes are at high levels in Aided colleges in comparison with the other categories. Self-financing engineering colleges show the lowest level in Supplementary Processes. Research and Development activities are very limited in the under graduate engineering colleges, among which autonomous colleges are somewhat better (56%) and self-financing colleges are the weakest (32%).

The factors like location of the college, experience & exposure of the faculty and vision of the management might be influencing the level of these factors. Unavailability of postgraduate programmes might be reducing the chances of research work in most of these institutes. Inadequacy of faculty may also contribute to this situation.

9.2 Resource factors: Among the seven Resource factors, three are found to be significantly different under the four styles of managements. Table 5 gives the result of multiple comparison tests and Table 7 gives the mean values of the Resource factors for the four categories.

Adequacy of faculty is not a problem for Autonomous engineering colleges (79%) and Government engineering colleges. But, this is a major issue for Self-financing colleges. Only Government engineering colleges seem to be superior with respect to student intake. Aided programmes stand at the top with respect to the Financial resources. Government programmes seemed to be weak with respect to this resource.

9.3 Outcome Factor: The outcome factor of the programme 'Student performance' is significantly varying from categories to categories of programmes. Results of multiple comparison tests are shown in Table 5. Table 8 displays the mean value of the Outcome factor of each of the four management styles.

Student Performance is high in Government engineering colleges and Autonomous engineering colleges when compared to that of other categories of colleges. Self-financing programmes are the weakest in this factor also. Inadequacy of

faculty along with poor quality of incoming students might be the reason behind the poor performance of students in the Aided and Self-financing programmes.

9.4 Management Factors: There is no significant difference between the different categories of programmes with respect to Management factors (Table 5). Mean values of these factors are given in Table 9.

The study reveals that, in general, managements of engineering programmes are committed to achieve the goals and also have good leadership capacity. But the planning and monitoring mechanisms are not working properly and they are unable to create a work culture of Participatory Management. It can be suspected that the involvement of faculty in decision-making is very less and the powers are still centralized with the administrators. Performance Appraisal systems appear to be weak in engineering programmes irrespective of the categories. Quality control and improvement mechanisms might not be working satisfactorily in the engineering colleges and hence, intervention of external agencies like AICTE is essential to ensure a continuous of improvement of quality of education provided by these colleges.

10. Conclusions

In general, the performances of Autonomous colleges are found to be superior to those of other categories of programmes especially that of Self-financing colleges. Supporting processes like Supplementary Processes, Industry-Institute interactions and R & D activities, which promote informal interactions among the students and with the experts from various fields are inadequate in most categories of engineering colleges. The outcome of the programmes viz, Student Performance is not at a satisfactory level in most of the programmes. Any problem related to Resources is not visible from the study. Management of programmes can be treated only as average in terms of planning, participation and performance appraisal. More initiatives are needed to improve the Processes and Management, which ultimately may lead to the improved outcome of the programmes.

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Table 1. Factors and groups of PROM model

Seventy variables (Parameters) of NBA	*Factors extracted*	*Major group*
Decentralization and Delegation, Involvement of faculty, Transparency	1. Participatory Management	Management
Leadership, Efficiency, Attitude, Motivation	2. Leadership Efficiency	Management
Mission & Goals, Commitment and Effectiveness	3. Commitment to achieve goals	Management
Planning & monitoring and incentives	4. Planning and Monitoring	Management
Maintenance budget, Development resources and budget, Capital resources, Operational budget	5. Financial Resources	Resources
Office equipment, Hostels, canteen, transportation and medical facilities	6. Supplementary Physical Resources	Resources
Land, Building and Support services – water, electricity communication	7. Main Physical Resources	Resources
Attitudes, Involvement, Commitment, Skill Up gradation, Workload, Performance appraisal.	8. Performance Appraisal & Development	Management
Recruitment procedures, Number, Qualifications/Skills	9. Supporting Staff Adequacy	Resources
Recruitment procedures, number, qualification and development programmes.	10. Faculty Adequacy	Resources

Academic Results, Admission to Post Graduate Courses, Performance in competitive Examinations, Placements and Employer's Feedback	11. Student Performance	Outcome
Admission Criteria and number of admissions	12. Student Intake	Resources
Syllabus, Implementation of the Instructional Programme, Library, Computing facilities, Laboratories, Workshops, Modernization and Budget for Consumables	13. Learning Facilities	Resources
Instructional aides, Evaluation Procedures and feedback,	14. Instruction, Evaluation and feedback	Processes
Working days, contact hours/ week, announcement and implementation of academic programmes.	15. Academic calendar	Processes
Student Counseling and Guidance, Extra & Co-curricular Activities, Alumni Information, Professional Society Activities, Entrepreneurship Development	16. Supplementary Processes	Processes
Industry participation and curriculum planning, Consultancy, Continuing education and industrial internship for the faculty, Project Work	17. Institute initiatives	Processes
Extension Lectures, Industrial Visits and Training, Placement	18. Industry Initiatives	Processes
Institutional Budget for Research and Development, Academic/Sponsored/Industrial Research and Development, Publications and patents	19. R&D Activities	Processes

Table 2. Categorization of samples (Engineering Programmes)

Category of Engineering Colleges	*Number of Programmes*
1. Autonomous Colleges	39
2.Government Colleges	25
3. Aided Colleges	17
4. Self – financing Colleges	80

Table 3. Preparation of data for Hypothesis testing

Anderson Darling Normality Test			*Levene's test for Homogeneity of variances*		*Action taken*
Factor	A squared	p-value	Test statistic	p-value	
PM	2.602	0	2.53	0.06	Box Cox transformation + ANOVA
LE	1.789	0	3.06	0.03	Box Cox transformation+ ANOVA
CA	9.512	0	1.304	0.28	Kruskal Wallis Test
FR	2.551	0	1.46	0.23	Kruskal Wallis Test
SPR	2.609	0	1.12	0.35	Kruskal Wallis Test
SI	1.561	0	2.85	0.04	Box Cox transformation + ANOVA
AC	2.608	0	0.67	0.57	Kruskal Wallis Test
LF	0.38	0.4	5.41	0.001	Weighted Least Square + ANOVA
FA	0.59	0.123	9.25	0	Weighted Least Square + ANOVA
StP	1.1	0.007	4.29	0.006	Box Cox transformation + ANOVA
IEF	0.52	0.18	5.51	0.001	Weighted Least Square + ANOVA
SP	2.39	0	2.61	0.05	Box Cox transformation + ANOVA
PlN	1.61	0	2.91	0.04	Box Cox transformation + ANOVA
MPR	2.24	0	2.4	0.07	Box Cox transformation + ANOVA
PAD	0.3	0.59	2.31	0.08	Weighted Least Square + ANOVA
SSA	0.61	0.11	2.12	0.1	ANOVA
II	0.71	0.06	0.42	0.74	Kruskal Wallis Test
IyI	0.35	0.47	2.26	0.08	Weighted Least Square + ANOVA
R&D	0.73	0.06	0.77	0.51	Kruskal Wallis Test

Table 4. Results of Hypothesis tests

Hypothesis testing			
Kruskal Wallis Test			
Factor	*Chi-square*	*Degrees of freedom*	*p-value*
Commitment to Achieve Goals	1.59	3	0.66
Financial Resources	9.45	3	0.023
Supplementary Physical Resources	11.84	3	0.08
Academic Calendar	15.26	3	0.002
Institute Initiatives	23.64	3	0
Research & Development	45.12	3	0
ANOVA Test			
Factor	*F*	*Degrees of freedom*	*p-value*
Participatory Management	1.14	3	0.34
Leadership Efficiency	2.25	3	0.09
Student Intake	2.95	3	0.04
Learning Facilities	1.54	3	0.21
Faculty Adequacy	11.8	3	0
Student Performance	18.37	3	0
Instruction, Evaluation & Feedback	1.97	3	0
Supplementary Process	3.67	3	0.01
Planning & Monitoring	.26	3	0.86
Main Physical Resources	2.25	3	0.8
Performance Appraisal & Development	1.68	3	0.17
Supporting Staff Adequacy	1.64	3	0.183
Industry Initiative	14.96	3	0

Table 5. Results of multiple comparison tests between the four categories of programmes

Significantly different Factors among various styles of management				
t-tests with Hochberg adjustments				
Factors	*Category (I)*	*Category (J)*	*Mean difference (I - J)*	*p-value*
Faculty Adequacy	Autonomous	Self-financing	10.51	0
	Government	Self-financing	6.86	0.011
Student Intake	Autonomous	Self-financing	30.07	0.023
Student Performance	Autonomous	Aided	8.61	0.03
	Autonomous	Self-financing	12.08	0
	Government	Aided	10.27	0.013
	Government	Self-financing	13.74	0
Supplementary Process	Aided	Self-financing	60.6	0.009
Industry Initiatives	Autonomous	Self-financing	38.08	0
	Government	Self-financing	40.14	0
Wilcoxon rank sum tests				
Factors	*Category (I)*	*Category (J)*	*W*	*p-value*
Financial Resources	Autonomous	Government	404	0.03
	Government	Aided	230.5	0.001
	Government	Self-financing	661	0.009
Instruction Evaluation and Feedback	Autonomous	Government	374.5	0.002
	Autonomous	Aided	36	0
	Autonomous	Self-financing	3179	0.002
Academic Calendar	Autonomous	Government	330	0.024
	Autonomous	Aided	55	0.028
	Autonomous	Self-financing	1673	0.001
Institute Initiatives	Autonomous	Self-financing	4129	0
	Aided	Self-financing	3674	0.002
Research & Development	Autonomous	Government	658.5	0.034
	Autonomous	Aided	325	0.004
	Autonomous	Self-financing	3783	0
	Government	Self-financing	3885	0.001
	Aided	Self-financing	3738	0.011

Table 6. Mean values of Process factors in four categories of programmes

Category	*Mean values of Process factors (%)*					
	IEF	*AC*	*SP*	*IyI*	*II*	*R&D*
Autonomous	72	83	64	68	61	56
Government	67	78	63	69	56	47
Aided	70	75	70	60	61	52
Self-financing	68	78	60	57	48	32

Table 7. Mean values of Resource factors in four categories of programmes

Category	*Mean values of Resource factors (%)*						
	FA	*SSA*	*SI*	*FR*	*MPR*	*SPR*	*LF*
Autonomous	79	68	73	70	77	71	73
Government	76	71	98	63	82	62	73
Aided	73	66	80	73	89	64	70
Self-financing	69	66	80	70	77	62	74

Table 8. Mean value of the Outcome factor in four categories of programmes

Category	*Mean value of the Outcome factor (%)*
	SP
Autonomous	69
Government	71
Aided	61
Self-financing	57

Table 9. Mean values of Management factors in four categories of programmes

Category	*Mean values of Management factors (%)*				
	PM	*LE*	*Pln*	*CA*	*PAD*
Autonomous	64	69	63	71	60
Government	65	72	60	72	59
Aided	57	65	62	70	59
Self-financing	60	70	62	71	57