



A comparative study of engineering colleges in India & abroad using six sigma metrics

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ABSTRACT

The study has been done on the basis of questionnaire survey in the twenty-degree engineering colleges from West Bengal and foreign countries by random selection, ten colleges from each to measure the current or baseline performance level. The feedback for this questionnaire survey has been considered independently for service providers such as administrators, faculties, other supporting staff as well as students who receive these services and are direct customers. A total of 2168 persons have been surveyed from the 20 colleges. The baseline or current performance level of the colleges has been assessed based on the sigma level through quantification of the survey questionnaire consisting of eight enablers. Each enabler contains several questions or drivers. A seven-point scale has been designed for each driver ranging from “Unsatisfactory” to “Outstanding”.

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Introduction

In the recent past, many private engineering colleges have come up along with a few more Government colleges in West Bengal. Furthermore, a trends are there in West Bengal to go USA ,UK or other countries to study engineering.

While the Government colleges in West Bengal charge between Rs. 4800 to 48000 per annum per student depending upon the engineering stream, the private colleges charge between Rs. 70,000 to 1, 40,000 per annum per student but the foreign colleges have charge beyond the range of the average people.

Moreover, there exists a feeling in the society at large that most of these private institutions are not up to the mark in terms of delivering the quality education that makes the students market-worthy. In this backdrop, it has been decided to undertake this study to assess the ‘as is’ situation of the engineering colleges in West Bengal as well as foreign engineering colleges measured through Six Sigma metrics based on the feedback obtained from survey questionnaire. Side by side, identification of vital few weak areas has been made through application of Pareto Analysis of defects per million opportunities (DPMO) and the internal benchmark level is considered for the colleges. It goes without saying that it is possible to achieve the benchmark sigma level once appropriate remedial measures are taken corresponding to the identified weak areas even under the existing set up. Certainly, breakthrough kind of improvement is possible to achieve provided much better resources and infrastructure are brought in.

Survey Method

A questionnaire (Annexure 1) has been designed to survey the perceptions of different stakeholders (faculties, students, administrators and other supporting staff) taking cue from the paper (Parasuraman, A. 1988) that discussed five dimensions for assessing service quality [SERVQUAL] consisting of tangibles, reliability, responsiveness, assurance, and empathy. Survey has been done from July 2012 to December 2012.

It can be seen in Table 2 as to how many drivers or questions drive the enablers. For each driver, driving an enabler, a seven-point scale has been developed ranging from ‘outstanding’ to ‘unsatisfactory’ in line with the Likert Scale (Helman, M., 2006; Wilson, J.R et al., 2002).

Operational Definition

Enablers: - These are the entities that determine how the things are done in an engineering college to have direct bearing on the key performance results.

Drivers: - These are the specific questions framed in a questionnaire corresponding to different ‘enablers’. The replies for these drivers are taken in a 7-point scale ranging from ‘outstanding’ (AA) to ‘unsatisfactory’ (D).

DPMO: - Defects per million opportunities or DPMO is a measure of process performance. It is defined as

$$DPMO = \frac{1,000,000 \times \text{number of defects}}{\text{number of units} \times \text{number of opportunities per unit}}$$

Defects: - It is the number of ‘D’s (‘Unsatisfactory’ tick mark) for an enabler that is responded by different people – faculties, administrators, other supporting staff and students.

Unit: - It is the number respondents who have responded in this study for any enabler through survey questionnaire. It can also correspond to the number of filled in questionnaire.

Opportunity: - It is the product of number of respondents and number drivers for an enabler.

Measuring Six Sigma Level (Metrics)

The following summarizes Six Sigma nomenclature, basic relationships, yield relationships, and standardized normal distribution relationships for Z that will be described henceforth: Nomenclature: -

- Number of departments of Indian Institute Technology, Kanpur = m
- Defects = D

Table 1: Charges of Engineering Colleges.

Year	Charges of Government Engineering Colleges	Charges of Private Engineering Colleges
West Bengal, India	Rs.4800-48000/-	Rs.70, 000-1,40,000/-
Foreign countries	Rs.20, 00000/- to Rs.18, 00000/- (\$40,000-\$36,000)	

Table 2: Seven-point Questionnaire Format

Enabler	Driver	Seven point scale						
		Performance Indicator (AA to D)						
Placement	2 drivers/questions	AA	A+	A	B+	B	C	D
Infrastructure	8 drivers/questions	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
Students	16 drivers/questions							
Faculties	8 drivers/questions							
Supporting staff	3 drivers/questions							
Curricula/courses	5 drivers/questions							
Administration	25 drivers/questions							
Innovation /Research activities	8 drivers/questions							

Table 3: Ranking of Different Colleges.

New ranking	Institution	Present sigma level	Benchmark Sigma level	Weak Areas
1	Massachusetts Institute of Technology (MIT) United States	6	0	Not applicable
2	University of California, Berkeley United States	5.6	5.8	Financial Administration,
3	Stanford University United States	5.24	5.5	Financial Administration,
4	California Institute of Technology (Caltech) United States	5.1	5.3	Financial Administration,
5	University of Cambridge United Kingdom	4.9	5.0	Financial Administration
6	Kharagpur IIT, West Bengal, India	2.19	3.43	Student
7	Faculty of Engineering & Technology, Jadavpur University, West Bengal, India.	2.21	3.44	Students, Curricula, Administration (Academic)
8	National Institute of Technology, Durgapur, West Bengal, India.	2.28	3.42	Administration (academic)
9	Institute of Engineering & Management, Salt Lake, Kolkata, West Bengal, India	2.18	3.48	Placement, Infrastructure
10	Burdwan Institute of Technology, Burdwan University, West Bengal, India.	3.08	3.42	Placement, Administration (financial), Innovation
11	Carnegie Mellon University United States	3.0	3.41	Financial Administration, Placement.
12	Imperial College London United Kingdom	3.0	3.40	Financial Administration, Placement.
13	Georgia Institute of Technology United States	2.99	3.48	Financial Administration, Placement
14	Govt. College of Engineering & Ceramic Technology, Kolkata, West Bengal, India	2.98	3.45	Placement, Students, Administration (academic), Innovation
15	University of Tokyo Japan	2.98	3.44	Infrastructure, Curricula, Academic Administration.
16	Institute of Jute Technology., Kolkata, West Bengal, India	2.98	3.43	Placement, Innovation
17	Jalpaiguri Govt. Engineering. College, Jalpaiguri, West Bengal, India.	2.97	3.41	Infrastructure, Students, Faculties, Curricula, Academic Administration, Innovation.
18	Haldia Institute of Technology, Haldia, West Bengal, India	2.95	3.41	Placement, Students, Curricula, Innovation.
19	University of Toronto Canada	2.94	3.56	Placement, Infrastructure, Students, Curricula, Academic administration, Financial administration
20	Bengal Engineering & Science University, Shibpur. Howrah, West Bengal, India	2.94	3.55	Placement, Infrastructure, Students, Curricula, Academic administration, Financial administration

Annexure 1

Enabler	Driver	Question	Performance Indicator						
			AA	A+	A	B+	B	C	D
(1) Placement	1	How is the performance of your institute regarding placement in different organizations?	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	2	How is your assessment about remuneration and other benefits by the prospective employers for students' employment?	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
(2) Infrastructure (Provide your assessment about infrastructure and allied resources of your institute)	3	Existence of adequate number of classrooms.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	4	Infrastructure in the class rooms like LCD projector, overhead projector, writing board, writing pen, adequate sitting arrangement, light, air etc.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	5	Laboratories with adequate state of the art equipment, machine etc.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	6	Library with adequate number of meaningful books and journals with easy accessibility.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	7	Library with e-resources for easy accessibility.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	8	Hostel accommodation .	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	9	Seminar halls.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	10	Auditorium	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	11	Competence of students admitted in your institute	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
(3) Students (kindly provide your assessment about these issues in your institute)	12	The level of difficulty in getting admitted in your institute through admission tests.	Most difficult	Very difficult	Reasonably difficult	Difficult	Not so difficult	Easy	Very easy

	13	Extent of compromising scores of admission tests through other influences like management quota, contribution to development fund etc.	Most uncompromising	Quite uncompromising	Reasonably uncompromising	Uncompromising	Not so uncompromising	Compromising	Very much compromising
	14	Provision of scholarships for superior performance.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	15	Provision of penalties for inferior performance.	Heaviest penalty	Quite heavy penalty	Reasonable penalty	penalty	Marginal Penalty	Insignificant penalty	No penalty
	16	Project work on practical industrial / organizational problems.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	17	Knowledge augmentation in the interface between industry and your institute (mandatory industry visit).	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	18	Dissertation on meaningful theoretical aspects.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	19	Project / dissertation reports.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	20	Presentation of project / dissertation work through audio visual aids.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	21	Kind of evaluation of projects/ dissertation	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	22.	Kind of evaluation of 'theoretical' papers.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	23	Kind of evaluation of 'practical' papers.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	24	Kind of formal feedback provided on faculties about their teaching.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	25	Accessibility of faculties during scheduled classes.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	26	Accessibility of faculties beyond scheduled classes.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
(4) Faculties	27	How good are the faculties regarding their knowledge level in their respective subjects?	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory

	28	How good are they in effectively communicating their subject knowledge?	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	29	How much willingness is reflected by faculties to share their knowledge?	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	30	Rate the faculties on fair/ proper evaluation of answer scripts.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	31	Rate the faculties on timely evaluation of answer scripts.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	32	Rate the faculties on providing feedback to students on their weak areas.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	33	Rate the faculties about extending helping hand to overcome the weak areas.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	34	Rate the academic freedom enjoyed by the faculties in choosing the areas they pursue for teaching, training, research, and consultancy.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
(5) Supporting staff (give your assessment about the cooperation you get from the supporting staff belonging to the categories mentioned here)	35	Library Assistants.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	36	Laboratory Assistant.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	37	Demonstrator / Technical Assistant.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
(6) Curricula / courses (Give your assessment about these aspects for your institute)	38	Extent of earning through self-financing courses.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	39	Extent of academic autonomy enjoyed by your institute.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	40	The kind of teaching load a faculty has to bear per week.	Very heavy teaching load	Heavy teaching load	Reasonably high teaching load	Moderate teaching load	Marginal teaching load	Very insignificant teaching load	No worth-mentionable teaching load
	41	Relevance of curricula as per the present societal or industrial needs.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory

		42	Scope for updating the curriculum from time to time to bring it as per the present day needs	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
(7) Administration (give your assessment about your institution regarding these issues)	Academic Administration	43	The process of admission of students	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		44	Extent of fair recruitment of faculties	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		45	The extent of fair recruitment of other supporting staff	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		46	Conducting examination	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		47	Timely publication of results	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		48	Updating curricula	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		49	Maintaining interaction /liasoning with the affiliating university.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		50	Analysis of feedback from students	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		51	Corrective or preventive actions taken based on students' feedback	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		52	Corrective or preventive action taken on potential or actual employers' feedback	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		53	Interaction with the former students of the institute.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		54	Provision of academic flexibility in working hours.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		55	Extent of taking appropriate decisions on crucially important academic matters.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		56	Promptness in taking administrative decision.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		57	Student Teacher ratio.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		58	Student Computer ratio.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		59	Extent of protection of autonomy from Governmental interference.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		60	Extent of protection of autonomy from political interference.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory

		61	Interaction with guardians.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
Administration	Financial Administration	62	Adequacy of budget provision for planned or developmental expenditure like buildings, equipment, computers and other infrastructure.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		63	Utilization of planned revenue budget.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		64	Utilization of planned capital budget.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		65	How well is the management of the non-plan fund meant for salaries, wages etc.?	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		66	How easy or smooth is the sanctioning or approval process?	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		67	How satisfactory is the quality of financial auditing of your institute?	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
	Financial Administration									
(8) Innovation /Research activities		68	Quantum of publications in national or international journals conference proceedings.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		69	Quality of publications.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		70	Number of faculties with only graduate degree.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		71	Number of faculties with only postgraduate degree.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		72	Number of faculties with Ph.D.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		73	Number of faculties pursuing Ph.D.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		74	Performance of your institute about receiving prestigious awards by the faculties or research scholars.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory
		75	Performance of your institute about the number of patents by the faculties or research scholars.	Outstanding	Excellent	Very Good	Good	Satisfactory	Marginal	Unsatisfactory

- Unit = U
 - Opportunities for a defect = O
 - Yield = Y
- Basic Relationships
- Total opportunities for an enabler: $TOP = U \times O$
 - Defects per opportunity: $DPO = \frac{D}{TOP}$
 - Defects per million opportunity: $DPMO = DPO \times 10^6$
- Yield relationships
- Throughput yield: $Y_{TP} = e^{-DPO}$
 - Defects per opportunity: $DPO = -\ln(Y_{TP})$
 - Rolled throughput yield: $Y_{RT} = \prod_{i=1}^m Y_{TPi}$
 - Total defects per opportunity = $-\ln(Y_{RT})$
 - Normalized yield: $Y_{norm} = \sqrt[m]{Y_{RT}}$
 - Defects per normalized opportunity: $DPO_{norm} = -\ln(Y_{norm})$
- Standardized Normal Distribution Relationships for Z
- $Z_{equiv} \approx Z \approx N(0;1)$
 - Z “long-term”: $Z_{LT} = Z_{equiv}$
 - Z “short-term” relationship to Z “long-term” with 1.5 standard deviation shift:
 $Z_{ST} = Z_{LT} + 1.5_{shift}$
 - Z Benchmark: $Z_{Benchmark} = Z_{Y_{norm}} + 1.5$

An alternative way to arrive at sigma level is through the following equation.

$$\text{Sigma quality level with 1.5 sigma shift} = 0.8406 + \sqrt{29.37 - 2.221 \times \ln(ppm)}$$

(Breyfogel, F.W., 2003)

ANALYSIS AND RESULTS

It has been found that the Six Sigma level different colleges range from 2.12 to 6.

Based on the sigma level attained by different colleges, a ranking of the colleges has been made and is furnished in Table 3. In order to identify the root causes for the weak areas, Pareto analysis (Juran et al., 1988) has been carried out for the corresponding drivers. Based on the Pareto analysis, the “vital few” drivers as well as enablers, which are common for all the college have been found and the corresponding enablers are noted down (see Table 3).

Conclusion

The overall ratings in terms of six-sigma level of engineering colleges in West Bengal and foreign countries range from 2.12 to 6. It can be seen from Table 3 that the Government Engineering colleges by and large outperform its counterpart's i.e. Private Engineering colleges in West Bengal state of India. Not only that, Kharagpur IIT and Jadavpur University of West Bengal are competent enough to the world class engineering colleges as their ranks are standing within first 10 colleges.

Recommendations

It is needed to establish more engineering colleges in West Bengal like Kharagpur IIT and Jadavpur University as they belong in world-class level and the study cost in these two colleges is very small in comparison to foreign universities.

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