ENHANCING THE QUALITY OF ENGINEERING EDUCATION INSTITUTIONS (EEIs) THROUGH GAP ANALYSIS

Sri N. Chandra Shekhar[1)]
K. Narayana Rao[2)]
K. Venkata Subbaiah[3)]

1) Faculty of Mechanical Engineering, Department of Technical Education, Government of Andhra Pradseh, India.
2) Faculty of Mechanical Engineering, Government Polytechnic, Visakhapatnam, India
3) Faculty of Mechanical Engineering, College of Engineering, Andhra University, Visakhapatnam, India

Abstract: Engineering will be challenged as never before to shape the nature and quality of life in the twenty-first century. Engineering education will be at the forefront of the effort to meet this challenge. The aim of this study was to determine the students' preferences based on the quality gap of various services provided by Engineering Education Institutions (EEIs) by using an originally SERVQUAL instrument among fresh engineering graduates. In this study, a total of 200 students who have attended the Graduate Apprenticeship Counseling programme were selected randomly and asked to complete a questionnaire which measured students' perceptions and expectations on services provided by the EEIs.
The quality gap of educational services was determined based on differences between students' perceptions and expectations on thirty two items of service quality. Factor Analysis (FA) was carried out to identify the underlying dimensions in the service quality items. In this study, service quality items having higher quality gap are factor analyzed. The results help to focus on items which need immediate attention to enhance the quality of EEIs.
Keywords: Factor Analysis, SERVQUAL, Quality gap, Professionalism, Integrated education.

1. INTRODUCTION

Engineering education is very much an engineering service and it too requires effective delivery system. Engineering education system that is highly adaptable to the demands of the future should be able to produce well-groomed professional engineers, able to work together efficiently in teams to identify and solve complex problems in industry, academe, government and society.

Given the rapidity of technological change, it is essential that the education system prepare students to function productively as engineers (whether in industry, government, or academe) over the full course of a career. Ideally, the education engineers obtain at the undergraduate level will be broad enough to provide a strong basis not only for a career in engineering but also for careers in other professions. In practice, the engineering education system has undergone only limited and sporadic changes and like all established enterprises, it resists large scale change. But the time for such change is now at hand.

The education system must continually change to reflect the emerging directions of the engineering profession and the evolving needs of the "customer" (engineering student). To this effect, the quality of services provided by the Engineering Education Institutions need to be assessed from the student's point of view from time to time and changes made accordingly. Parasuraman et al., [1] opined that regardless of the type of service, consumers basically use the same criteria to assess quality.

Parasuraman et al., [2] developed a 22-item instrument called SERVQUAL for assessing customer perceptions of service quality in service and retailing organizations and defined service quality as the gap between consumers' expectations and perceptions. SERVQUAL was adopted to assess the quality in various service sectors like banking, transportation, hospitals, education, etc. Extensive literature available on SERVQUAL instrument and its application in service sector is reviewed. A lack of knowledge of these key factors by administrators might lead to their misallocating resources while attempting to improve their institution's quality. Such efforts could result in student dissatisfaction with the institution, with subsequent deleterious consequences [3]. In some studies, "gap analysis" is used to develop a number of questions in order to compare what students "look for" (expect) and what they "experience" on a course. It has been suggested that for some services the SERVQUAL instrument needs considerable adaptation [4] and that items used to measure service quality should reflect the specific service setting under investigation, and that it is necessary in this regard to modify some of the items and add or delete items as required [5].

Velasco [6] discussed that an educational institution has to disseminate knowledge and develop skills in the students that are needed to be productive for gainful employment in the discipline one is trained for.

The end result should be total customer satisfaction. "Higher education has been increasingly recognized as a service industry and as a sector; it must strive to identify the expectations and needs of its clients, who are the students" [7]. Bateson [8] stated that "Quality is generally considered an attribute in consumer choices". The education sector that produces the human resource has a pivotal role in the quality movement that demands total quality approach in the education system to live up to the requirements of the industry [9].

Even though it is risky to view students as customer, but given the current atmosphere of higher education marketplace, there is a new moral prerogative that student have become "customer" and therefore can, as fee payers, reasonably demand that their views be heard and acted upon [10]. Any educational establishment represents a multiple stakeholder situation and caters to the needs of its key stakeholders such as students, alumni, parents, recruiters, faculties, supporting staff, government, society and administrators [11], [12]. Further, perceived quality is determined by "the gap between expected quality and experienced quality".

Efthimia Staiou [13] expressed that in the context of an analogy with a manufacturing organization, higher education institutions produce graduates . Students move through the various courses required for a degree, as raw material flows through the successive stages of a manufacturing process. T.D. Juwaheer [14] used SERVQUAL to determine the students' views of the quality of academic and administrative services provided by the University of Mauritius. Mohar bin Yusof et al., [15] examined the expectations of prospective students, parents of prospective students and first year university students and identified the factors influencing their preferences in selecting a particular higher education institution.

Otavio Jose de Oliveira et al., [16] proposed an adaptation of the SERVQUAL scale's generic questionnaire for the higher education service sector and presented the main results of its application in students of the production engineering program at São Paulo State University in Brazil. Hishamuddin Fitri Abu Hasan et al., [17] used SERVQUAL to establish the relationship between service quality dimensions and overall service quality (tangibility, responsiveness, reliability, assurance and empathy) and students' satisfaction in private higher education Institutions in Malaysia [17]. Faganel [18] carried out analysis on students and professors of Slovenian Business School and established the most important determinants of quality for students and professors [18].

However, there has been little research seeking to identify key factors of educational quality from the students' viewpoint. In this study, an attempt is made to identify the critical student needs through service quality gap analysis with an aim to enhance the quality of EEIs.

2. SERVQUAL

Service quality is a general opinion the client forms regarding its delivery, which is constituted by a series of successful or unsuccessful experiences. To improve the quality in its services, a company will have to identify the gaps in service quality and manage them. But gaps are not the only means clients use to judge a service. SERVQUAL instrument based on the gap model uses five broad-based dimensions as judgment criteria: reliability, tangibility, responsibility, security and empathy.

These dimensions are briefly addressed below:
- *Reliability:* Is the service provided by the company reliable? Does the company provide service as promised? Reliability is a measure of a company's consistency and certainty in terms of performance. Reliability is the most important dimension for the consumer of services;
- *Tangibility:* how are the company's physical installations, equipment, people and communication material? Since there is no physical element to be assessed in services, clients often trust the tangible evidence available while making their assessment;
- *Responsibility:* are the company's employees willing and capable enough to provide fast service? The company and employee receptiveness towards clients is assessed here;
- *Security:* are the company's employees well-informed, educated, competent and trustworthy? This feature measures the company's competence, courtesy and precision; and
- *Empathy:* Does the company provide careful and personal attention? This is the capacity of a person to experience another's feelings.

In the context of engineering education, which is also an engineering service, an inventory of service quality items was identified. 32 items for measuring student – perceived service quality were adopted and considered for the questionnaire survey. The list of items is shown in Table 1.

Table 1: Items related to service quality of EEIs - The following 32 items are identified for questionnaire survey.

Items
1. Skill development
2. Consumables for lab practicals
3. Professional activities (Seminars, workshops, etc)
4. curriculum as per industry needs
5. Industry participation Consultancy
6. Guidance & counseling
7. Scope for R&D

8.	Adequate facilities/ infrastructure to render service
9.	Acquisition of multi tasking skills
10.	Prompt service
11.	Computing facilities
12.	Ability to work in any field
13.	Hostels, canteen, transportation & medical facilities
14.	Land, building & support services – water, electricity, communication
15.	Good evaluation system
16.	Ability to establish own firm
17.	Expert lectures
18.	Cleanliness, orderliness, systematic and methodical
19.	Reinforcement in basic maths/ sciences
20.	Knowledge about engineering and related fields
21.	Working hours convenient to students
22.	State of art equipment in labs
23.	Specific needs of students are understood
24.	Courteousness and willingness to help
25.	Transparency in procedures
26.	Industrial training during study
27.	Individual attention to the students
28.	Instructional aids, learning materials
29.	Orientation towards design and development of innovative engineering products
30.	Students' best interests are considered
31.	Ability to solve challenging engineering problems
32.	Personal attention by all teaching/ other staff

3. METHODOLOGY

This exploratory study analyzed the students' expectations and perceptions of service quality provided by the EEIs. Questionnaires were designed according to the SERVQUAL model of measuring the gap between customers' expectations and perceptions.

3.1 Identification of stake holders

Any educational establishment represents a multiple stake holder situation and caters to the needs of its stake holders such as students, alumni, parents, recruiters, faculty, supporting staff, government, society and administration.

Nevertheless, it is generally accepted that students are the primary customers and other potential stake holders such as alumni, parents, employers, employees, government, industry and society may be considered as secondary customers. In this study, students are considered as stakeholders.

3.2 Survey instrument

Questionnaire based survey is one of the most popular instruments to obtain data. Different types of questionnaires are self-administered questionnaire, e-mail questionnaire and web based questionnaire.

The questionnaire may be designed by means of brain storming, literature review, expert opinion, etc. The internal consistency of the questionnaire is determined by Cronbach's alpha technique which gives an indication of reliability.

3.3 Data Collection

To obtain the expectations and perceptions of stake holders, data is collected in two forms, i.e. expectations of service quality of an engineering educational institution in general and the perceived service quality of the institution in particular. Along with this, data about the respondents is also obtained. The sample adequacy is tested by means of KMO Measure of sampling adequacy.

3.4 Analysis

Gap Analysis:
The data collected on expectations and perceptions is analysed by means of SPSS 17.0 statistical package.

The mean service quality gap is obtained by the difference in mean perceptions scale and mean expectations scale. Significant difference between average ratings of expectations and perceptions is calculated by means of Paired samples t-test.

Factor Analysis:
Factor Analysis is carried out for the service quality gap that exists between the expectations and perceptions of students. Items with higher negative quality gap are identified and factor analysed to determine the existence of underlying factors in the Quality gap.

4. CASE STUDY

In this study, the students' expectations and perceptions of service quality provided by EEIs was analysed based on the responses received from engineering graduates who attended the Graduate Apprenticeship Counseling programme at GICE, Visakhapatnam, India.

Twenty industries have participated in the Counselling. Questionnaires were designed according to the SERVQUAL model for measuring the gap between

customers' expectations and perceptions.

A total of 200 students were administered the questionnaires and 130 useful responses were received, i.e. a response rate of 65%. The survey instrument (self-administered questionnaire) consists of three sections:

Table 2: Details of demographic survey

Branch of study	No. of candidates appeared	No. of candidates given questionnaire	No. of candidates responded	Boys	Girls
Electrical & Electronics	233	60	41	21	20
Electronics & Communication	185	59	43	20	23
Mechanical	90	29	12	10	2
Computer Science	86	22	16	4	12
CSIT	4	2	1	0	1
Information Technology	29	10	6	2	4
Instrumentation	34	11	6	3	3
Chemical	16	3	2	1	1
Civil	4	2	1	1	0
Aeronautical	1	1	1	1	0
Architecture	1	1	1	0	1
TOTAL	**599**	**200**	**130**	**63**	**67**

(i) Statements focused on student expectations of an ideal Engineering Education Institution in general, (ii) Statements focused on student perceptions of service quality by the EEI where they graduated from, and (iii) Demographic data about the respondents (branch of study, year of study, gender and institution attended).

In the first two sections, a 5-point Likert scale was adopted. The scale was arranged so that "strongly agree" was coded as five, while "strongly disagree" was coded as one. Each of the 32 items in the questionnaires was associated with the number one to five and to complete their answers respondents were asked to circle the number that best matched their opinion.

Demographic information is presented in Table 2 and includes the following characteristics of the participants; gender, branch of study, institution last studied (not provided in the table for reasons of anonymity). The respondents remained totally anonymous.

The quality gap was determined based on differences between perception scale and expectation scale. A negative result indicates that perceptions are below expectations, revealing the service failures that generate an unsatisfactory result for the client. A positive score indicates the service provider is offering a better than expected service.

5. RESULTS & DISCUSSION

The statistical package, SPSS (17.0), was used to analyze the data received from the questionnaire. To enable ease of data entry, questions were precoded before hand. Data were analyzed using descriptive and multivariate statistical analysis.

5.1 Internal consistency of the Student Questionnaire

A Kaiser – Meyer – Olkin Measure of Sampling Adequacy (MSA) of 0.728 for Expectations and 0.730 for Perceptions were obtained. The values suggest that the sample adequacy was meritorious.

The internal consistency of the questionnaire is determined by the Cronbach's Alpha (also known as the coefficient alpha) technique. Cronbach's Alpha can be conceived as a measure of the inter-correlations between the various constructs used to measure a variable. The Cronbach's Alpha for the entire student questionnaire is 0.88 for Expectations scale and 0.892 for Perceptions scale. These higher values of Cronbach's Alpha are an indication of reliability.

Table 3 – Paired sample t-test

Pair	Mean	SD	t	Sig(2-tailed)	Pair	Mean	SD	t	Sig (2-tailed)
1	-1.871	0.845	-22.268	0.000	17	-1.386	1.378	-10.108	0.000
2	-0.663	0.752	-8.865	0.000	18	-1.109	1.139	-9.782	0.000
3	-0.584	0.962	-6.103	0.000	19	-0.515	1.073	-4.82	0.000
4	-0.802	1.217	-6.624	0.000	20	-0.901	1.091	-8.3	0.000
5	-0.67	1.378	-4.861	0.000	21	-0.871	1.189	-7.366	0.000
6	-2.277	1.234	-18.548	0.000	22	-1.366	0.946	-14.519	0.000
7	-0.426	0.829	-5.162	0.000	23	-0.822	1.062	-7.776	0.000
8	-0.109	1.216	-0.9	0.37	24	-0.901	1.253	-7.226	0.000
9	-1.762	1.258	-14.077	0.000	25	-0.307	1.247	-2.474	0.015
10	-1.416	0.897	-15.856	0.000	26	-1.337	1.143	-11.756	0.000
11	-0.683	0.916	-7.497	0.000	27	-0.842	0.987	-8.567	0.000
12	-1.446	1.005	-14.459	0.000	28	-1.416	1.07	-13.296	0.000
13	-0.416	0.962	-4.344	0.000	29	-1.327	1.05	-12.7	0.000
14	-0.198	1.4	1.421	0.158	30	-0.812	1.294	-6.306	0.000
15	-1.475	1.331	-11.138	0.000	31	-1.079	1.181	-9.187	0.000
16	-1.426	1.424	-10.064	0.000	32	-2.01	1.17	-17.258	0.000

5.2 Gap Analysis

The paired samples statistics comparing the service statements tested the significant mean difference between students' expectations and perceptions of service quality. Paired samples t-test showed that there is a significant difference between average ratings of expectations and perceptions suggesting that the respondents distinguished between SERVQUAL dimensions (Table 3)

The Expected Mean Score, Perceived Mean Score and Service Quality Gap of 32 items are shown in Table 4. It is observed that there is a negative quality gap in 31 out of 32 items which show that students' perceptions were not meeting their expectations.

Table 4 – Service quality gap between students' perceptions and expectations

Question	Expected SQ (E) Mean Score	Perceived SQ (P) Mean Score	SQ Gap (P-E)	Question	Expected SQ (E) Mean Score	Perceived SQ (P) Mean Score	SQ Gap (P-E)
Q1	4.57	2.68	-1.89	Q17	4.06	2.69	-1.37
Q2	4.33	3.66	-0.67	Q18	4.26	3.14	-1.12
Q3	3.96	3.38	-0.58	Q19	3.8	3.29	-0.51
Q4	3.73	2.94	-0.79	Q20	3.84	2.91	-0.93
Q5	3.38	2.71	-0.67	Q21	3.8	2.89	-0.91
Q6	4.66	2.38	-2.28	Q22	4.13	2.73	-1.4
Q7	4.12	3.67	-0.45	Q23	3.97	3.12	-0.85
Q8	3.27	3.16	-0.11	Q24	3.89	2.98	-0.91
Q9	4.06	2.28	-1.78	Q25	3.2	2.88	-0.32
Q10	4.49	3.07	-1.42	Q26	3.57	2.24	-1.33
Q11	4.15	3.46	-0.69	Q27	3.39	2.55	-0.84
Q12	4.64	3.2	-1.44	Q28	3.67	2.29	-1.38
Q13	4.1	3.65	-0.45	Q29	3.94	2.62	-1.32
Q14	2.86	3.05	0.19	Q30	3.71	2.89	-0.82
Q15	3.26	1.8	-1.46	Q31	3.76	2.67	-1.09
ST16	3.72	2.29	-1.43	Q32	4.69	2.66	-2.03

5.3 Factor Analysis

The mean service quality gaps for all thirty two service quality items are determined. The higher the negative quality gap, the lesser is the chance of students' expectations meeting the perceptions' level. Hence, fifteen items having higher mean service quality gaps were identified and analysed through Factor Analysis. Table 5 shows the eigen values, % of variance explained and cumulative % of variance explained.

Principal Component analysis of the 15 items was conducted followed by varimax rotation to examine their dimensionality. The criteria for the no. of factors extracted was determined on the basis of percentage of variance extracted by the factors reach at least 45% of the cumulative variance [19]. Items with eigen value equal to or greater than 1 were chosen for interpretation. Factor analysis identified five underlying dimensions (factors).

Table 5: Rotated Components Factor Analysis for Service Quality

Description	Factors				
	1	2	3	4	5
Eigen Values	2.54	1.668	1.532	1.277	1.13
Variance Explained (%)	16.93	11.12	10.21	8.51	7.53
Cum Variance Explained (%)	16.93	28.05	38.26	46.77	54.30

The Factor loading matrix obtained through rotated component matrix is shown in Table 6.

Table 6: Rotated Component Matrix

	Factors				
	1	2	3	4	5
Q1	**.509**	.478	.009	.174	.041
Q6	**.677**	.111	.040	.147	-.003
Q9	-.037	-.064	**.740**	.051	.229
Q10	.257	-.151	.042	**.726**	-.188
Q12	.147	.345	**-.410**	-.233	.224
Q15	**.714**	.124	.141	.094	.100
Q16	.056	.007	**-.557**	.108	.501
Q17	**.518**	.128	-.254	.303	-.223
Q18	.152	.081	.009	**.663**	.420
Q22	.199	**.762**	-.013	-.081	.089
Q26	**.614**	-.412	-.140	-.320	.194
Q28	-.006	**.715**	.059	-.013	-.084
Q29	.060	.040	**.535**	-.301	-.062
Q31	.087	.153	**.465**	.198	.047
Q32	.020	-.006	.111	-.024	**.796**

From the matrix, the highest factor loading for each item is identified. The results indicate that items 1, 6, 15, 17 and 26 combine to define the first factor; items 22 and 28 combine to define the second factor; the third factor contained the items 9, 12, 16, 29 and 3; items 10 and 18 combine to define the fourth factor and item 32 is identified in the fifth factor. The underlying dimension for each factor is identified and shown in Table 7.

Earlier studies have revealed the evolution of various factors such as teaching, attitude, convenience, learning outcomes, personality development, etc.

This is the first time probably that two new dimensions namely, professionalism and integrated education are identified in this study. Professionalism encapsulates skills development and their application to serve the society.

Table 7: Factors and their underlying dimensions

Factor (Underlying Dimension)	Items
Factor 1 (Professionalism)	• Skill development • Student Guidance and Counselling • Good evaluation system • Expert lectures • Industrial training during study
Factor 2 (Facilities)	• State of art equipment in laboratories • Instructional aids, learning materials
Factor 3 (Integrated Education)	• Acquisition of multitasking skills • Ability to work in any field • Ability to establish own firm • Orientation towards design and development of innovative engineering products • Ability to solve challenging engineering problems
Factor 4 (Responsiveness)	• Prompt service • Cleanliness, Orderliness, Systematic & Methodical
Factor 5 (Empathy)	• Personal attention by all teaching/ other staff

Ability to work in multifarious fields, entrepreneurial ability and to solve challenging engineering problems forms the integrated education factor. The other three dimensions, i.e. facilities, responsiveness and empathy are consistent with the original SERVQUAL dimensions.

6. CONCLUSION

The quality of an engineering education institution in any developing country is sometimes viewed as a measure for social and technological development and economic growth. The objective of this study was to identify the needs of the primary stake holder; the student with a view to improve the overall quality of an engineering education institution.

SERVQUAL, the survey instrument used in the study is found to be appropriate and generated results conducive to the study. The larger negative quality gap in the service quality items selected for Factor Analysis

indicated that perceptions are far below the expectations of students. Professionalism and integrated education have evolved as the two most important factors during Factor Analysis.

Professionalism factor included skill development along with guidance and counseling, good evaluation system, expert lectures and industrial training during study. The **integrated education** factor was associated with acquisition of multitasking skills, ability to work in any field, entrepreneurial ability, orientation towards design and development of innovative engineering products and ability to solve challenging engineering problems.The other factors namely, **facilities, responsiveness and empathy** included items related to modern equipment in labs, instructional aids, learning materials, prompt service, personal attention by all teaching and other staff, orderliness, cleanliness, etc.

In conclusion, it is worth underscoring that the objective proposed in this study to enhance the quality of EEIs by identifying the student needs was appropriately met.

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