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A framework for analysing quality in education settings

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In this paper, an attempt has been made to propose a measuring instrument known as EduQUAL for evaluation of quality in Technical Education System (TES). Factor analysis has been carried out on responses obtained through cross-sectional questionnaire survey on various items to validate dimensionality of the instrument and it is found that 28 items loaded above 0.5. Neural network models have been proposed to assess the degree of satisfaction of various stakeholders in TES. In doing so, not only the areas of improvement but also the minimum number of items satisfying all the stakeholders can be identified. Finally, the Quality Function Deployment (QFD) method is used to provide guidelines for administrators of the institutions to prioritize improvement policies needs to be implemented.

Keywords: Service quality; Expectations; Perceptions; Customer; EduQUAL; Sensitivity analysis

1. Introduction

Quality has now become a key competitive weapon to serve and attract primary customers (students) in the education sector due to the stiff challenge arising from the increasing number of domestic and foreign institutions and diminishing funding patterns. In the parlance of service organizations, quality in an educational establishment may be measured using multiple-item survey instruments like SERVQUAL and its modified versions (Berry *et al*. 1985, Parasuraman *et al*. 1985, 1988, 1991, 1994a, 1994b). The instrument defines the "gap" between expectations of a customer from the service provider and perception of the service experienced by the customer (popularly known as P-E gap) and treats it as a measure of service quality. 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 (Garretson 2004, Temponi 2005). However, service items happen to be dissimilar for different stakeholders because their mode of interaction with the institution and expectations from it vary widely. Therefore, fixing the norms that suit all the stakeholders is the real challenge for administrators of an education set up. To this end, this study aims to develop a uniform construct (minimum number of items) of service that satisfies

the service requirement of important stakeholders. To address this issue, a survey instrument known as EduQUAL, specifically proposed for education sector, is used to measure the satisfaction level of different stakeholders. Since neural network is considered a "brain metaphor" of information processing, it is demonstrated that effective use of neural network models can precisely evaluate service quality (Tam and Kiang 1992, Hoefer and Gould 2000, Nordmann and Luxhoj 2000). Finally, a framework is proposed in this paper to help the administrator of education to identify system design requirements using quality function deployment.

2. Stakeholders in technical education system

An education set up characterizes a large number of interested parties such as students, faculty, supporting staff, administration, parents of the students, alumni, domestic and offshore partners, career advisor, government, industry (recruiters), society, etc., each having its own expectations and perceptions. Hence, at the outset, it is desirable to identify various potential customers in an educational set up and determine their specific needs to maintain customer oriented service (Spanbauer 1995, Natarajan 2002) before implementing any quality improvement programme. Nevertheless, it is generally accepted that students are the primary customers and other potential stakeholders such as alumni, parents, employers, employees, government, industry and society may be considered as secondary customers (Downey *et al*. 1994, Madu *et al*. 1994, Owlia and Aspinwall 1996, Sirvanci 1996). Since students are the prime users of the TES, their satisfaction is vital for determining areas of improvement. An institute maintains good relations with alumni to assess future prospects of the institute and fosters life-long learning through its various outreach and continuing education programmes. Recruiters absorb the quality students of an institute in their organization whereas the parents supply the students to be imparted quality training in an institute. In this study, four key stakeholders such as students, alumni, recruiters, and parents are considered.

3. Development of EduQUAL

"SERVQUAL" is extensively used as a service quality measurement instrument due to its simple structure, generalization capability and ease of use (Philip and Hazlett 1997). Since quality of service largely depends on human behaviour, the quality dimensions of the measuring instrument differ in different service settings. For example, "empathy" and "responsiveness" are more significant in the healthcare sector, whereas "reliability" is important in transportation. Therefore, "SERVQUAL" dimensions, and items under each dimension, are modified to suit a particular application (Weitzel *et al*. 1989, Saleh and Ryan 1991). In the education sector, intangibility and lack of physical evidence of service makes perceptions of service quality a complex composition and poses difficulties for analysis. The TES has different kinds of stakeholders with different backgrounds and varied behavioural patterns. In order to evaluate the quality at aggregate level fitting to most of the key stakeholders, an attempt has been made to propose a new instrument, known as EduQUAL, for the measurement of education quality in technical institutions. Forty-three survey items relevant to TES compiled from various sources are considered in this study using "SERVQUAL" as a basis.

3.1 *Data collection*

A questionnaire is prepared containing 43 items and a respondent needs to answer in terms of Likert-type scale from 1 to 7 (1, strongly disagree and 7, strongly agree). Data are collected

from students, alumni, parents of students and recruiters of different technical institutions (both private and government) across India through e-mail/postal/personal contacts by means of questionnaire survey. The expectations and perceptions on 43 items from the respondents related to quality of the organization are compiled. A final question of whether the stakeholders will recommend their friends and relatives to study in that institute is asked and treated as the output of the 43 questions. This study used probability as well as non-probability sampling for selecting the institutions and the respondents. The list of institutions, students, alumni, and industries are collected through accessing different websites and personal contacts. The survey was conducted through different modes of collecting responses over a period of 6 months (from December 2004 to June 2005). It was carried out in four zones of the country, *i.e.*east, west, north and south. For the students' survey, a total of 589 questionnaires were sent and 448 responses (76%) were received. Responses were screened based on completeness, rational scoring and adherence to scale and finally 408 (nearly 69%) responses were considered for further analysis. For the alumni survey, 478 questionnaires were sent, 257 responded (52%) and the usable responses were 250 (nearly 50%). Similarly, for the parents' survey, 478 questionnaire were sent and 262 responses (55%) were received, out of which 246 (52%) were used for analysis. For recruiters, a total of 286 questionnaires were sent, 124 responses (43%) received and 120 responses were considered for further analysis.

3.2 *Data analysis*

The useful responses for all stakeholders (1024) were tested to examine the validity and reliability of the scale to enable us to obtain a quantitative and statistically proven identification of requirements of the stakeholders. The test for quantitative validity was conducted by factor analysis of the 43 proposed variables using the Principal Component Method followed by the varimax rotation to ensure that they are important and suitable for the model using SPSS 13.0 package. Twenty-eight items loaded more than 0.5 are kept under five dimensions as shown in table 1. The five dimensions are defined as follows.

- Learning outcomes: ability to provide the promised service dependably and accurately.
- Responsiveness: willingness to help customers, provide prompt service.
- Physical facilities: physical facilities, equipment, personnel and communication material.
- Personality development: overall development of students' personality, enhancement of knowledge.
- Academics: expert faculties, individualized attention to the customer.

Percentage of total variance explained is found to be 75% which is an acceptable value for the principal component varimax rotated factor loading procedure (Johnson and Wichern 2002). The internal consistency of the actual survey data are tested by computing the Cronbach's Alpha (α). As shown in the table 1, the value of alpha for each dimension is 0.860, 0.752, 0.909, 0.897 and 0.861, respectively, and the combined alpha value for all the items is 0.950, which is well above the acceptable value of 0.70 for demonstrating internal consistency of the established scales (Nunnally 1988). The value of Kaiser–Meyer–Olkin (KMO), which is a measure of sampling adequacy, is found to be 0.782, indicating that the factor analysis test has proceeded correctly and the sample used is adequate, since the minimum acceptable value of KMO is 0.5 (Othman and Owen 2001). Therefore, it can be concluded that the matrix did not suffer from multicollinearity or singularity. The results of the Bartlett test of Sphericity shows that it is highly significant (sig. $= 0.000$), which indicates that the factor analysis processes is correct and suitable for testing multidimensionality (Othman and Owen 2001). Thus, the statistical tests for EduQUAL have resulted that the proposed items and dimensions of the

Table 1. Factor analysis of EduQUAL items (Chronbach Alpha = 0.950).

Dimensions	EduQUAL items	Source	Factor loadings
Learning outcomes ($\alpha = 0.860$)	1. Training on state-of-the art technology	• Developed by self	• 0.809
	2. Practical orientation in education	• Owlia and Aspinwall (1998)	• 0.779
	3. Adaptability to modern techniques	• Developed by self	• 0.690
	4. Design of course structure based on job requirements.	• Developed by self	• 0.644
	5. Problem-solving skills	• Owlia and Aspinwall (1998)	• 0.625
	6. Sense of social obligation	• Developed by self	• 0.556
Responsiveness ($\alpha = 0.752$)	7. Prompt service at service departments	• Developed by self	• 0.856
	8. Courteousness and willing to help	• Owlia and Aspinwall (1998), developed by self	• 0.739
	9. Cleanliness, orderliness, systematic and methodical	• Scheerens and Bosker (1997)	• 0.695
	10. Transparency of official procedure, norms and rules	• developed by self	• 0.556
	11. Adequate facilities/infrastructure to render service		• 0.533
Physical facilities ($\alpha = 0.909$)	12. Well-equipped laboratories with modern facilities	• Redfern (1980), Horne and Pierce (1996), Owlia and Aspinwall (1998)	• 0.762
	13. Comprehensive learning resources	• Developed by self	• 0.752
	14. Academic, residential and recreational facilities	• Developed by self	• 0.750
	15. Aesthetic views of facilities	• Developed by self	• 0.658
	16. Training in a well-equipped communication laboratory	• Developed by self	• 0.613
	17. Opportunities for campus training and placement	• Harvey and Knight (1996)	• 0.558
	18. Effective classroom management	• Owlia and Aspinwall (1998)	• 0.533
Personality development ($\alpha = 0.897$)	19. Encouragement for sports games and cultural activities	• Developed by self	• 0.874
	20. Enhancement of knowledge	• Developed by self	• 0.809
	21. Adherence to schedule	• Developed by self	• 0.753
	22. Extra academic activities	• Developed by self	• 0.602
	23. Recognition of the students	• Trethowan (1987)	• 0.527
Academics ($\alpha = 0.861$)	24. Adequacy of subject teachers	• Owlia and Aspinwall (1998)	• 0.856
	25. Available regularly for students' consultation	• Owlia and Aspinwall (1998)	• 0.785
	26. Close supervision of students' work	• Horne and Pierce (1996)	• 0.632
	27. Expertise in subjects and well-organized lectures	• Horne and Pierce (1996), Owlia and Aspinwall (1998)	• 0.583
	28. Good communication skill of academic staff	• Developed by self	• 0.548

instrument are sound enough to measure the service quality in a technical education system and hence can be used for further analysis.

4. Measurement of service quality

The human decision-making process can be modelled using neural networks as they have the capability to predict an output, classify a given set of inputs into different groups (known

as pattern recognition), and incorporate heuristic criteria (Baily and Thompson 1990). As a neural network can effectively exploit and represent the non-linear relationship between the consumer satisfaction and their perception of the service, it can be used for modelling the decision-making of customers (Mittal *et al*. 1998).

4.1 *Design of models*

The responses obtained from different stakeholders for 28 items for their perceptions and expectations pertaining to TES are used to measure the quality through application of back propagation algorithm of neural networks. A three-layer network architecture is considered – input layer containing I number of nodes, a hidden layer with H number of nodes and an output layer with a single node. A single question regarding overall customer evaluation of the service quality is considered as the output. The number of nodes in the hidden layer (H) is decided based on equation (1).

$$H = 2\sqrt{(I+1)} \tag{1}$$

From the literature it is evident that neural network models, when tested in a different service sector with different survey items, may indicate significantly different results. Therefore, it is decided to consider four well-known service quality models for each stakeholder. The models are as follows:

- **Model-I (P-E gap model):** This network model uses the traditional SERVQUAL-based gap for the evaluation of service quality (Parasuraman *et al*. 1988).
- **Model-II (P-only model):** Low reliability of SERVQUAL-based gap model in specific applications leads to propose the perception-only model known as SERVPERF (Cronin and Taylor 1994, VanDyke *et al*. 1999). In this model, customer perceptions only are used as input to the network.
- **Model-III (E-P gap model):** Sometimes the customer undertakes a service experience with some preconceived expectations, and thereafter develops a perception of that experience. Hence, service quality could be measured as expectations minus perceptions or E-P gap (Ravi *et al*. 2002).
- **Model-IV (E & P model):** Customer expectations are generally accepted as a part of the service experience but their exact role in the overall evaluation of service quality is still controversial. Therefore, the interactions of expectations and perceptions independently may be considered without a predefined relationship between them (Ravi *et al*. 2002).

4.2 *Performance of the models*

NeuNet Pro version 2.3 package (June 2001) is used for the training and testing of the normalised survey data due to its fast generalisation capability. All the models are trained with 75% of data for each stakeholder by systematically varying the learning parameter (less than 0.1), momentum parameter (near to zero) and the number of cycle. The rest data (25%) are used for testing the models. The numbers of correct outputs are noted until the root mean square error (RMSE) is minimized to a reasonable value. A model is said to perform best when higher percentage of correct outputs is observed for same RMSE value. The values of correct outputs for different stakeholders for P-E gap model are found to be 77%, 90%, 70% and 82% for students, alumni, parents and recruiters, respectively. The RMS error ranges from 0.15 to 0.25 for students, alumni and parents whereas the range is from 0.07 to 0.08 for recruiters. Considering the maximum percentage of correct outputs with minimum RMS error, P-E gap

Table 2. Results of neural network models.

Stakeholders	Neural network models	Learning parameter	Momentum parameter	Number of cycles	RMS error	Percentage of correct output
Students	P-E Gap	0.10	0.02	293,380	0.21	77*
	P-only	0.09	0.03	18,680	0.22	62
	E-P Gap	0.08	0.01	461,380	0.25	69
	E & P	0.09	0.02	379,195	0.21	69
Alumni	P-E Gap	0.07	0.01	21,775	0.15	90*
	P-only	0.09	0.03	30,855	0.15	60
	E-P Gap	0.08	0.01	17,725	0.17	70
	E & P	0.10	0.03	3730	0.19	60
Parents	P-E Gap	0.08	0.02	4150	0.15	70*
	P-only	0.08	0.01	7975	0.17	70
	E-P Gap	0.09	0.03	6500	0.18	70
	E & P	0.10	0.02	3980	0.19	69
Recruiters	P-E Gap	0.09	0.03	7095	0.07	70*
	P-only	0.09	0.01	3350	0.08	70
	E-P Gap	0.09	0.03	7320	0.07	50
	E & P	0.09	0.03	2760	0.07	50

*Indicates the highest percentage of correct output.

model is found to be the best model for predicting quality for all the stakeholders considered in this study.

The second best model is found to be E-P model for students and alumni whereas P-only model for parents and recruiters. This indicates that parents and recruiters do not overemphasis on expectations but judge the quality of education in an indirect way from their wards and jobseekers. It is worthy to mention that E&P is the least favourable among all models for all the stakeholders. Since statistical evidence also favours EduQUAL, it can be used for predicting service quality in TES and identifying deficiency in the system according to four important stakeholders of the system. In that sense, sensitivity analysis of the best model will help to identify the deficiency in the system.

5. Sensitivity analysis

Sensitivity analysis is carried out for the best models (P-E model). Sensitivity analysis is used to study the impact of changes in service performance along the various items (inputs) on customer evaluation of service quality (output). The inputs in the test samples are varied one at a time systematically up and down 10% ($\pm 10\%$) from its base value holding other items at their original values. The scaled change in output is calculated with the current input increased by 10% and the current input decreased by 10%. The scaled change in output is given by:

$$\textit{scaled change in output} = \frac{\textit{Scaled output for 10\% increase in input} - \textit{scaled output for 10\% decrease in input}}{2} \tag{2}$$

Thus, the results obtained are the scaled output change per ten percent change in input. The calculation is repeated for every input (P-E gap) and for every fact and then averaged across all the facts yielding a single mean scaled change in output for each input service criterion (table 3).

Increasing input (gap) from its base value causes decrease in service quality due to the widening of the gap, whereas reduction of gap indicates an increased service quality evaluation.

Table 3. Sensitivity analyses.

Inputs	Students	Alumni	Parents	Recruiters
1. Training on state-of-the art technology	−0.091[7]	−0.154[3]	−0.234[2]	−0.065[9]
2. Practical orientation in education	−0.004[16]	−0.032[10]	+0.038	−0.030[12]
3. Adaptability to modern techniques	+0.123	+0.132	+0.042	−0.120[2]
4. Design of course structure based on job requirements	−0.214[4]	+0.031	+0.208	+0.062
5. Problem-solving skills	−0.008[15]	+0.066	+0.002	−0.185[1]
6. Sense of social obligation	+0.033	−0.023[13]	+0.109	+0.104
7. Prompt service at service departments	+0.062	−0.009[14]	−0.123[8]	+0.007
8. Courteousness and willing to help	−0.088[9]	−0.112[4]	−0.028[14]	+0.004
9. Cleanliness, orderliness, systematic and methodical	−0.135[6]	−0.063[8]	−0.133[6]	+0.018
10. Transparency of official procedure, norms and rules	+0.240	+0.024	−0.081[10]	+0.068
11. Adequate facilities/infrastructure to render service	+0.032	+0.002	+0.240	+0.031
12. Well-equipped laboratories with modern facilities	−0.300[2]	−0.009[15]	+0.039	+0.060
13. Comprehensive learning resources	−0.009[14]	−0.075[6]	−0.004[15]	−0.033[11]
14. Academic, residential and recreational facilities	−0.032[11]	+0.046	−0.079[11]	+0.090
15. Aesthetic views of facilities	+0.026	+0.027	+0.139	+0.041
16. Training in a well-equipped communication laboratory	+0.070	−0.088[5]	+0.189	−0.026[13]
17. Opportunities for campus training and placement	−0.089[8]	−0.062[9]	−0.075[12]	−0.070[8]
18. Effective classroom management	+0.065	+0.003	−0.244[1]	−0.077[6]
19. Encouragement for sports, games and cultural activities	−0.140[5]	−0.290[1]	+0.087	−0.009[14]
20. Enhancement of knowledge	+0.020	+0.087	+0.078	−0.074[7]
21. Adherence to schedule	+0.088	+0.106	−0.056[13]	+0.160
22. Extra academic activities	+0.556	+0.042	+0.091	+0.029
23. Recognition of the students	−0.030[12]	−0.026[12]	−0.179[3]	+0.088
24. Adequacy of subject teachers	+0.551	+0.031	+0.031	+0.008
25. Available regularly for students' consultation	−0.331[1]	+0.052	−0.124[7]	−0.099[4]
26. Close supervision of students' work	−0.023[13]	−0.028[11]	−0.151[4]	−0.060[10]
27. Expertise in subjects and well-organized lectures	−0.045[10]	−0.185[2]	−0.144[5]	−0.087[5]
28. Good communication skill of academic staff	−0.226[3]	−0.068[7]	−0.115[9]	−0.113[3]

Note: 1. The negative score for average scaled change in output scores per 10 percent variation in inputs is the norm. Percentage of negative score for various stakeholders: Students – 57%; Alumni – 53%; Parents – 53%; Recruiters – 50%.
2. The superscript in the table indicates the ascending order of negative values.

Logically, net effect of change in input (gap) results in negative score for average scaled change in output. About 50–60% of input items produce negative service quality changes as expected. The percentage of items produce negative scores are 57%, 53%, 53%, and 50% for students, alumni, parents and recruiters, respectively. However, positive or increased service quality is also obtained in all the cases. This irregularity may be attributed to the noisiness of the survey data. Noisy data exists when customer responding to survey have similar evaluation on individual question but different evaluation of the overall service quality. This results in similar input data for the neural network with very different corresponding outputs.

The values of scaled change in output for items having negative scores for each stakeholder are ranked in an ascending order (table 3). The larger negative mean effect value indicates a large change in the overall evaluation of service quality (outputs) with the same percentage change in gaps (inputs). Therefore, the items resulting in large negative mean effect are treated

as deficient items where improvements are needed. Using a threshold value of –0.1, there are six most important items that the students suggest for improvements. Similarly, alumni cite only four items as the most important quality factors that need to be improved. However, parents seem to be suggesting ambitious improvement plans (9 out of 15 items) to provide quality education in a TES. Similarly, the recruiters' ratings indicate that only three service items badly need improvement.

It is evident from table 3 that there are six common items rated negative score by all stakeholders. The six numbers of common items include training on state-of-the art technology (item 1), comprehensive learning resources (item 13), opportunities for campus training and placement (item 17), close supervision of students work (item 26), expertise in subjects and well-organized lectures (item 27) and good communication skill of academic staff (item 28). It implies that these six items have strong effects on service quality and the policy makers of the TES must focus on these areas for improving the satisfaction level of potential stakeholders. The present technical education system throughout the country urgently needs to modernize the syllabi and course curriculum keeping in view of rapid technological growth. Mostly, the institutions suffer from shortage of learning resources like books, journals, software, and training modules etc. causing serious impediments for independent growth of the students. The locational disadvantage and lack of industry–institute interaction squeezes job opportunity of the students. As far as teaching staff are concerned, vacancies exist in large number of institutions due to difficulties in getting the right faculty. Moreover, it is also difficult to retain existing faculties because they are not properly motivated to instill pride in their profession.

6. Implication for administrators of educational institutions

Educational administrators must contemplate to find out the ways and means to improve the deficiencies of at least minimum number of service items proposed by key stakeholders. In this regard, Quality Function Deployment (QFD), a powerful tool for converting customers' voice into engineering characteristics can be effectively used for identifying system requirements (Akao 1990, Mizuno and Akao 1994, Khoo and Ho 1996, Pitman *et al*. 1996).

In order to find out system design requirements, a QFD team is formed in a leading technical institute in Eastern India comprising of nine members representing major engineering branches, hall management and students' activity centre under the leadership of Dean (Academic Affairs). The team suggested five design requirements pertinent to six quality items (table 4). The initial ratings for the six common quality items are fixed by the team in a 1–10 scale as shown in figure 1 by judiciously converting negative scores of the items.

First of all the customer ratings for the customer needs are determined from the left correlation matrix of figure 1 using the following formula;

$$\textit{Customer rating} = Z_i + \left[\frac{1}{(n-1)}\right] \times \sum_{j \neq i}^{n} B_{ij} Z_j \tag{3}$$

where B_{ij} denote the relationship between customer needs, Z_i is the initial customer ratings.

Table 4. System design requirements.

Design requirements	Attributes
1. Continuous evaluation system	a. Course credit system. b. Performance monitoring through class tests, quizzes, assignments, mini projects, examinations,etc. c. Provision of time slots in academic curricula for counselling, advising and discussions. d. Timely evaluation of students' work in a fair and transparent manner. e. Exemplary punishment for academic indiscipline. f. Development of study materials and hand-outs.
2. Industry–institute interface	a. Industrial visits and training for students and faculties. b. Industrial consultancy and collaborative project works. c. Technology development and transfer.
3. Opportunities for knowledge up gradation	a. Attending and conducting seminars, conferences and workshops. b. Training for teachers including communication skills. c. Sufficient new addition of books, encyclopedia and journals. d. Fast and reliable IT services. e. Computational facilities, laboratory modernization, software, etc. f. Continuing education and outreach activities.
4. Management responsibility	a. Instilling sense of pride and commitment through able leadership, participatory management and motivational measures. b. Funds mobilization. c. Rewards and recognition for performers and guidance for non-performers. d. Fair, transparent and uniform administrative norms and procedures conductive enough to retain faculties. e. Delegation of authority and responsibility.
5. Technology-driven teaching aids	a. Modern visual instruments like OHPs, LCDs, Videos, Films, etc. in the classrooms. b. Prototypes, physical models, simulation and animated models, etc. c. Virtual classroom facilities.

The individual rating for each design requirement is obtained from the centre matrix using the following relation:

$$\textit{Design requirement} = \left(\frac{1}{n}\right) \times \left[\sum_{j}^{n} A_{ij} X_j\right] \tag{4}$$

where A_{ij} and X_j denote the relative importance of the ith characteristics with respect to the jth customer need in the relationship matrix and the importance of jth customer needs (customer ratings) and n is the number of customer needs.

The refined rating for each design requirement is calculated from the top matrix in a similar way using equation (3). The final ratings of design requirements are normalised by dividing each rating with the maximum available ratings. The results are shown in table 5.

It is evident from table 5 that the normalised refined ratings for the design requirements have maximum values in case of "Opportunities of knowledge up gradation" followed by "Continuous evaluation". The "Management responsibility" showed the lowest rating in this case. Therefore, the attributes listed under the "Opportunities of knowledge up gradation" can be emphasised more in a priority basis by the administrators of a TES followed by the attributes of

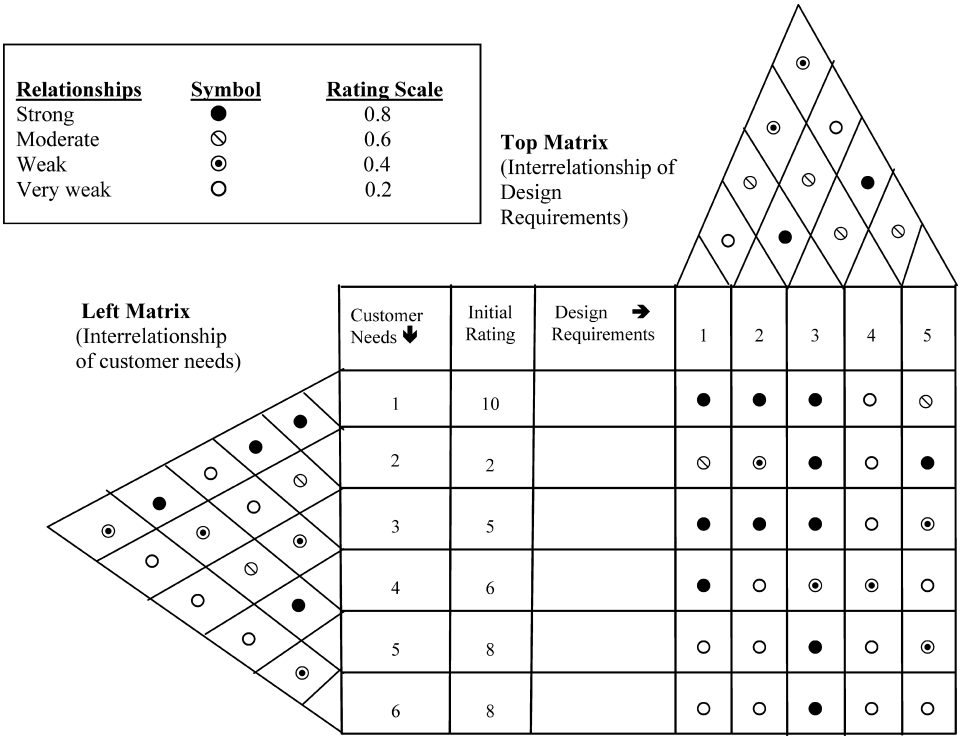

Figure 1. The house of quality.

Table 5. Ranking of design requirements.

Design requirements	Initial ratings	Refined ratings	Normalized refined ratings	Rank
1. Continuous evaluation system	5.29467	7.18147	0.73236	2
2. Industry–institute interface	4.26667	6.46493	0.65929	4
3. Opportunities for knowledge up gradation	7.02933	9.80593	1.00000	1
4. Management responsibility	2.18133	5.00660	0.51057	5
5. Technology-driven teaching aids	4.00933	6.48520	0.66135	3

"Continuous evaluation". The other design requirements such as "Industry–Institute Interface" and "Technology-driven teaching aids" can be taken up simultaneously in the next phase of the quality implementation programme since both of them showed almost the same normalized rating. Although "Management responsibility" has emerged as the least important design requirement, still its attributes are vital for system design in the overall implementation of the quality improvement program in a TES.

7. Conclusions

The major contribution of this paper is to provide a systematic integrated approach for modelling customer evaluation of service quality applied to technical education. The stakeholders in an educational setting range from students to recruiters with varying level of interaction

with the system and expectations from the system. An educational set up must satisfy the needs of such a wide range of stakeholders which is extremely difficult for implementing a quality control policy. Therefore, it is advisable to identify the minimum number of service items that suit all the stakeholders before implementing any quality improvement plan. To this end, EduQUAL, a survey-based model, has been developed especially to suit a technical education system. Four neural network models such as P-E gap, P-only, E-P gap and E & P models are developed for predicting the service quality for four stakeholders considered in this study. Through exhaustive experimentation, it has been observed that the P-E gap model is the best model. The study reconfirms that traditional P-E gap for defining quality outperforms other gap models. Sensitivity analysis of the best model enables to identify the deficient items suggested by all four stakeholders for providing guidelines to the policymakers. Finally, the study provides a framework for the identification of system design requirements for successful implementation of quality programmes with reference to the identified common service quality items using QFD. The results indicate that the attributes of "Opportunities of knowledge up gradation" should be implemented first and then the attributes of "Continuous evaluation" by the administrators of a TES. Next, "Industry–Institute Interface" and "Technology-driven teaching aids" can be taken up simultaneously in the next phase of the quality implementation programme. "Management responsibility" plays an important role in system design for the overall implementation of the quality improvement programme in a TES.

Although this study demonstrates the methodology for modelling customer evaluation of service quality in the education sector at an aggregate level, the approach is quite general and can be applied to any specific organization. However, we recommend identifying the customers at the first step and then meticulously finding out their requirements. The next step is to design a measuring instrument for particular application and can be used only after validating through statistical tests. In the third step, an appropriate neural network model may be developed and sensitivity analysis of the model enables to identify deficient items. It may be concluded that the neural network developed in this study to model education quality are adequate for predicting the overall evaluation of the technical education system by their stakeholders but not robust enough for sensitivity analysis indicating a need for future research.

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References

Akao, Y., *Quality Function Deployment: Integrating Customer Requirements into Product Design*, 1990 (Production Press Cambridge, Massachusetts).

Baily, D. and Thompson, D., Developing neural network applications. *AI Expert*, 1990, September, 34–41.

Berry, L.L., Zeithaml,V.A. and Parasuraman, A., Quality counts in service too. *Bus. Horizons*, 1985, May–June, 44–52.

Cronin, J.J. and Taylor, S.A., SERVPERF versus SERVQUAL: reconciling performance-based and perceptions-minus-expectations measurement of service quality. *J. Market.*, 1994, **58**, 125–131.

Downey, C.J., Frase, L.E. and Peters, J.J., *The Quality Education Challenge*, vol. 9, pp. 17–24, 1994 (Corwin Press Inc.: Thousand Oaks, CA).

Garretson, J.A., The meaning of quality: expectations of students in pursuit of an MBA. *J. Ed. Bus*., 2004, September 1.

Harvey, L. and Knight, P.T., *Transforming Higher Education*, 1996 (SRHE and Open University Press: Buckingham).

Hoefer, P. and Gould, J., Assessment of admission criteria for predicting students' academic performance in graduate business programs. *J. Ed. Bus.*, 2000, **75**, 229.

Horne, H. and Pierce, A., *A Practical Guide to Staff Development and Appraisal in Schools*, 1996 (Kogan Page: London).
Johnson, R.A. and Wichern, D.W., *Applied Multivariate Statistical Analysis*, 5th edn, 2002 (Prentice-Hall, Inc.: Englewood Cliffs, NJ).
Khoo, L.P. and Ho, N.C., Framework of a fuzzy quality function deployment system. *Int. J. Prod. Res.*, 1996, **34**, 299–311.
Madu, C.H., Kuei, C.H. and Winokur, D., TQM in the university: a quality code of honor. *Total Qual. Mngt*, 1994, **5**, 375–390.
Mittal, V., Ross, W.T. and Baldasare, P.M., The asymmetric impact of negative and positive attribute-level on overall satisfaction and repurchase intentions. *J. Market.*, 1998, **62**(3), 33–48.
Mizuno, S. and Akao, Y., *QFD, The Customer Driven Approach to Quality Planning and Deployment*, 1994 (Asian Productivity Organisation: Tokyo).
Natarajan, R., Emerging trends in engineering education – Indian perspectives, in *Proceedings of 16th Australian International Education Conference*, Hobart: 30 September – 4 October 2002.
NeuNet Pro Version 2.3, http://www.cormactech.com/neunet, June 2001.
Nordmann, L.H. and Luxhoj, J.T., Neural network forecasting of service problems for aircraft structural component grouping. *J. Aircr.*, 2000, **37**, 332–338.
Nunnally, J.C., *Psychometric Theory*, 1988 (McGraw-Hill: Englewood Cliffs, NJ).
Othman, A. and Owen, L., The multidimensionality of CARTER model to measure customer service quality (SQ) in Islamic banking industry: a study in Kuwait finance house. *Int. J. Islam. Finan. Serv.*, 2001, **3**, 1–12.
Owlia, M.S. and Aspinwall, E.M., Quality in higher education – a survey. *Total Qual. Mngt*, 1996, **7**, 161–171.
Owlia, M.S. and Aspinwall, E.M., A framework for measuring quality in engineering education. *Total Qual. Mngt*, 1998, **9**, 501–518.
Parasuraman, A., Zeithaml, V.A. and Berry, L.L., A conceptual model of service quality and its implication for future research. *J. Market.*, 1985, **49**, 41–50.
Parasuraman, A., Zeithaml, V.A. and Berry, L.L., SERVQUAL: a multiple-item scale for measuring customer perceptions of service quality. *J. Retail.*, 1988, **64**, 12–37.
Parasuraman, A., Berry, L.L. and Zeithaml, V.A., Refinement and reassessment of the SERVQUAL scale. *J. Retail.*, 1991, **67**, 420–450.
Parasuraman, A., Zeithaml, V.A. and Berry, L.L., Alternative scale for measuring service quality: a comparative assessment based on psychometric and diagnostic criteria. *J. Retail.*, 1994a, **70**, 201–230.
Parasuraman, A., Zeithaml, V.A. and Berry, L.L., Reassessment of expectations as a comparison standard in measuring service quality: implications for further research. *J. Market.*, 1994b, **58**, 111–124.
Philip, G. and Hazlett, S.A., The measurement of service quality: a new P-C-P attributes model. *Int. J. Qual. Reliab. Mngt*, 1997, **14**, 260–286.
Pitman, G., Motwani, J., Kumar, A. and Cheng, C.H., QFD application in an education setting: a pilot field study. *Int. J. Qual. Reliab. Mngt*, 1996, **13**(4), 99–108.
Ravi, S.B., Warren, W.F. and Jos, G.A.M. Modelling and evaluating service quality measurement using neural networks. *Int. J. Oper. Prod. Mngt*, 2002, **22**, 1162–1185.
Redfern, G.B., *Evaluating Teachers and Administrators: A Performance Objective Approach*, 1980 (Westview Press Inc.: New Jersey).
Saleh, F. and Ryan, C., Analyzing service quality in the hospitality industry using the SERVQUAL model. *Service Ind. J.*, 1991, **11**, 324–343.
Scheerens, J. and Bosker, R.J., *The Foundation of Educational Effectiveness*, 1997 (Oxford: Elseveir Science Ltd).
Sirvanci, M., Are students the true customers of higher education. *Qual. Progr.*, 1996, **29**, 99–102.
Spanbauer, S.J., Reactivating higher education with total quality management: using quality and productivity concepts, techniques and tools to improve higher education. *Total Qual. Mngt*, 1995, **6**, 519–537.
Tam, K.Y. and Kiang, M.Y., Managerial applications of neural networks: the case of bank failure predictions. *Mngt Sci.*, 1992, **38**, 926–947.
Temponi, C., Continuous improvement framework: implications for academia. *Qual. Assur. Ed.*, 2005, **13**, 17–36.
Trethowan, D., *Appraisal and Target Setting – A Handbook for Teacher Development*, 1987 (Harper and Row Publishers: New York).
Van Dyke, T.P., Prybutok, V.R. and Kappelman, L.A., Cautions on the use of the SERVQUAL measure to assess the quality of information systems services. *Decision Sci.*, 1999, **30**, 877–891.
Weitzel, W., Schwarzkoff, A.B. and Peach, E.B., The influence of customer service on retail stores. *J. Retail.*, 1989, **65**, 27–39.

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