A METHODOLOGY FOR EVALUATION OF SERVICE QUALITY USING NEURAL NETWORKS

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Abstract: *This paper analyzes literature to identify critical factors responsible for successful implementation of TQM. It is observed that only 21% of the total articles considered in this study focus on service sector. Literature also suggests that service quality comprises intangibility and behavioural aspects; hence its measurement and evaluation becomes extremely difficult. To address these issues, an instrument (referred as EduQUAL) is proposed and applied in education sector. The dimensionality of EduQUAL is validated through factor analysis. In order to predict quality in a multiple stakeholders environment like education, four neural network models based on back-propagation theory have been tested and P-E gap model is found to be the best model for all the stakeholders.*

Key Words: *TQM; Service Quality; Expectations; Perceptions; EduQUAL, Sensitivity Analysis*

1.0 INTRODUCTION

Total Quality Management (TQM) is an integrative philosophy of management for continuously improving the quality of product, process and services. The traditional Statistical Process Control (SPC) techniques, first proposed by Shewhart in 1931, are still widely used in manufacturing and service organizations. However, publication of Juran's famous "Quality Control Hand Book" in 1951 led to diversify the basic quality control theory into various pertinent areas viz., supplier management, employee involvement, team work, leadership, customer focus, service and strategic planning. In the last few decades, significant increase in research on TQM led to documentation of large volume of research articles, case studies and survey results. Several models for successful TQM implementation have been developed in academics as well as industries. Juran's Trilogy, Crosby's 14 point program, Deming's Chain Reaction, Malcom Baldrige National Quality Award, European Quality Award model and ISO 9000 Series are few noteworthy guidelines on TQM. It has been observed that most of the TQM studies revolve around manufacturing and little attention is attracted towards service industry. Services account for more than 75% of the GDP in most developed countries and this trend has been observed in developing countries also. Literature suggests that only 21% of research papers, case studies and popular articles focus on service sectors. It may be attributed to difficulties in measuring service quality due to intangibility characteristics. Therefore, this study attempts to focus on literature on TQM and its application in service sector. The study also proposes a novel way of measuring service quality and demonstrates the methodology in education sector.

2.0 CURRENT RESEARCH AND FUTURE TRENDS IN TQM

The literature survey of articles published in the last decade shows that a wide range of critical factors responsible for successful implementation of TQM have attracted the attention of the researchers. Interestingly, the set of critical factors considered and their complementation sequence widely vary across different types of industries [1]. This anomaly leads to difficulties in selecting the right choice of a set of TQM ideas suitable for a specific situation. However, TQM must be viewed as an integrated philosophy rather than a piece-meal approach.

One of the important factors of TQM as indicated in literature is the customer focus and satisfaction [2, 3]. The entire philosophy of TQM rests on customer orientation by devising methods and procedures to improve degree of satisfaction of customers. Customer satisfaction can only be achieved by rendering right quality, right quantity, at right time and at right cost of a product or service. This ultimately contributes profit and reputations building of an organization. [4, 5].

The main purpose of continuous quality improvement is to produce a better quality product/service than its predecessors. Quality can only be made better if improvement in quality of products, methods of production, material required, marketing quality strategy, quality system and human resources management can be achieved. Customer feedback is the key for providing opportunity for creating a management system which will consider continuous improvement as never ending activity. Of course, different quality award models such as Malcom Baldrige National Quality Award (MBNQA), European Quality Award (EQA) and ISO 9000 certification serve as the basic platform for successful implementation of TQM in a company.

Some of the key factors, which are given more emphasis by the researchers, have been considered in this study. The core concepts of Total Quality Management (TQM), Malcom Baldrige National Quality Award (MBNQA), European Quality Award (EQA) and ISO 9000 certification are referred while finalizing critical factors. Twenty (20) critical factors of TQM have been identified that enable successful implementation of TQM in any organization (Table1). In this study, articles from different journals for last eleven years (1994 to 2004) have been analyzed to determine the implementation of TQM philosophy in the context of identified critical factors. The number of articles that discuss the implementation methodology of TQM with the year of publication is presented as shown in the figure 1 and the coverage of twenty identified critical factors of TQM in figure 2.

Table 1: List of the Selected Critical Factors

Sl.No.	Critical Factors	Symbol	Sl.No.	Critical Factors	Symbol
1	Leadership (Top Management Commitment)	A	11	Employees Participation	K
2	Customer Focus and Satisfaction	B	12	Employees Appraisal, Rewards and Recognition	L
3	Policy and Strategic Planning	C	13	Quality Culture	M
4	Human Resources Management	D	14	Quality Assurance	N
5	Process Management and Control	E	15	Quality System	O
6	Product/Service Design and Control	F	16	Impact On Society	P
7	Continuous Improvement	G	17	Teamwork	Q
8	Supplier Management	H	18	Flexibility	R
9	Training	I	19	Zero Defect	S
10	Employees Satisfaction	J	20	Benchmarking	T

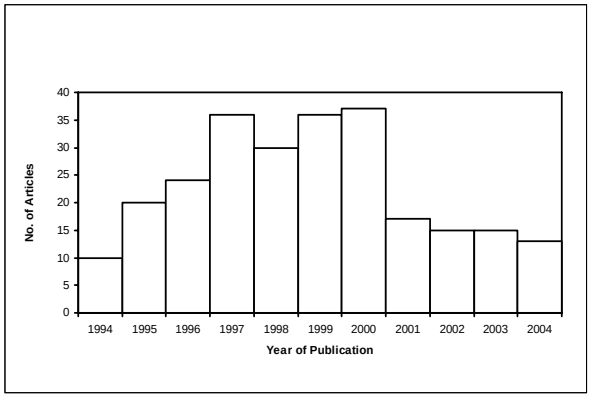

Figure 1: Number of Articles on TQM v/s Year of Publication

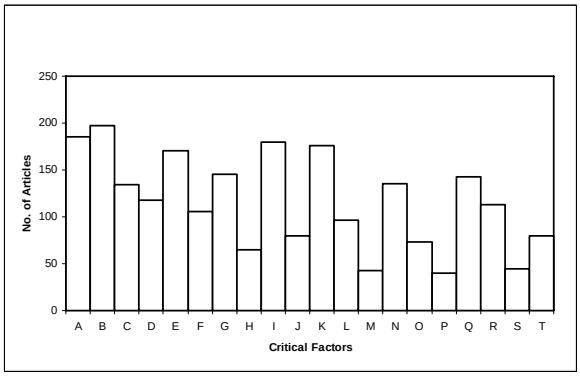

Figure 2: Coverage of TQM Factors in the Articles

Analysis of 256 different articles results in observation of an important trend that publication of articles related to TQM gradually increased from the year 1994 to

1996. Then, it remained more or less constant during the period 1997 to 2000. After the year 2000, publication of articles on TQM is gradually reduced in number (Figure-1). Moreover, initially the philosophy took momentum in Western countries and Japan and then these ideas are implemented in Eastern countries. However, initial period of implementation only is focused on manufacturing industries and later extended to service sector. Figure 2 clearly indicates that five critical factors such as leadership and top management commitment (185), customer focus and satisfaction (197), process management and control (170), training (180) and employees' participation (176) are widely covered in TQM literature. The next critical factors which are given importance in research papers are policy and strategic planning (134), human resources development (118), product/service design and control (106), quality assurance (135), team work (143), flexibility (113) and continuous improvement (145). The critical factors which are given least coverage in the articles surveyed in this study are supplier management (65), employees' satisfaction (80), employees' appraisal, rewards and recognition (96), quality culture (43), quality system (73), impact on society (40), zero defect (44) and bench marking (80). The figures in the parentheses indicate the number of articles.

It is also observed that only 21% articles out of total number of articles referred in this study relates to service sectors such as health care, transit system, transportation, tourism, education etc. that adopt the TQM principles. The low percentage of TQM adoption may be attributed to the intangible components associated with the service sectors. Therefore, it is decided to focus on the 'service quality' and its improvement in this study.

3.0 RESEARCH OBJECTIVES

One of the important components of TQM is the 'service quality' which may be viewed from three perspectives such as performance of the product, behavior of service provider's personnel and attitude of customers. The diverse viewpoint of service quality makes its control and improvement extremely difficult [6]. Among all service sectors, education sector, particularly technical education system (TES) has direct bearing on society for its growth and socio-economic development. To this end, development of a measurement instrument for education set up and methodology for assessment of quality is of prime importance for providing guidelines for the administrators of the institutions. In an educational set up, there are a wide range of stakeholders such as, students, alumni, parents, recruiters, faculties, supporting staff, government, society and administrators. They interact with the system in different ways and their expectations are also different. Therefore, the service items are likely to be different for different stakeholders. The administrators of education set up find it very difficult to fix the norms that suit all the stakeholders. Therefore, it is desirable to discover a uniform construct (minimum number of items) of service that meet the service requirement of key stakeholders and recommend the identified areas to the management for further improvements. To address these issues, a survey instrument known as EduQUAL, is proposed to suit education sector, which measures the satisfaction level of different stakeholders. Evaluation of service quality is attained by implementing a neural network approach [7, 8, 9]. Such an approach may enable one to address three fundamental issues. Firstly, the consideration of applying neural network adequately for modeling of customer evaluation of service quality in education. Secondly, since neural network is considered as 'brain metaphor' of information processing, it may be possible to get some insight into the issues related to how service quality is being currently measured and evaluated. Thirdly, the study demonstrates effective utilization of neural network models by the service providers for identification and improvements of the quality of service.

3.1 Development of EduQUAL

The 'SERVQUAL' is the most extensively used service quality measurement instrument because of easiness to use, possession of simple structure and capability of generalization [10]. Since quality of service largely depends on the human behavior, the quality dimensions of the measuring instrument differ in different service settings. Therefore, 'SERVQUAL' dimensions are modified in order to suit the particular service settings. Sometimes number of dimensions is changed or items under each dimension are modified to suit the particular application [11, 12]. In education sector, intangibility and lack of physical evidence of service persists. The perceptions of service quality in this sector have complex composition making it difficult to analyze. The TES has different classes of stakeholders with different backgrounds and varied behavioral 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.

3.2 Data Collection

A questionnaire is prepared containing forty three items compiled from various sources related to the education

quality. Data are collected from students and alumni of different technical institutions (both private and government), parents and recruiters across India through e-mail/postal mode/personal contacts by attaching the questionnaire for their expectations as well as perceptions related to quality of the organization as a whole. A respondent needs to answer in terms of Likert-type scale from 1 to 7 (1, strongly disagree and 7, strongly agree). A final question whether the stakeholders will recommend their friends and relatives to study in this institute is asked and treated as the output of the forty three questions. This study used probability as well as non-probability sampling for selecting the institutions and the respondents. The lists of institutions, students, alumni, and industries are collected through accessing different websites and personal contacts.

For 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 alumni's survey, 478 questionnaires had been sent, 257 responded (52%) and the usable responses were 250 (nearly 50%). Similarly, for 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%) were received and 120 responses were considered for further analysis.

3.3 Data Analysis

The useful responses (1024) are 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 forty three 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 14.0 package. Twenty eight items load more than 0.5 which are kept under five dimensions (Table 2). These 28 items with five dimensions constitute various variables for proposed instrument, EduQUAL. The items that failed to get loaded more than 0.5 are deleted from the questionnaire. Percentage of total variance explained is found to be 75% which is an acceptable value for the principal component varimax rotated factor loading procedure.

The internal consistency or the reliability of the actual survey data of stakeholders (students, alumni, parents and recruiters) are tested by computing the Cronbach's Alpha (α) with SPSS 14.0. The values 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 are above the threshold value 0.7 [13] (Table 2). 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 as the minimum acceptable value of KMO is 0.5 [14]. Therefore, it can be concluded that the matrix did not suffer from multicollinearity or singularity. The results of 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 [14]. Thus, the statistical and factor analysis tests for EduQUAL has suggested that the proposed items and dimensions of the instrument are sound enough to measure the service quality in a technical education system and hence can be used for further analysis.

Table 2: Factor Analysis of EduQUAL Items (Chronbach Alpha = 0.950)

Dimensions	EduQUAL Items	Source	Factor Loadings
Learning Outcomes (α = 0.860)	1. Training on state-of-the art technology.	Proposed by experts	0.809
	2. Practical orientation in education.	Owlia and Aspinwall(1998)	0.779
	3. Adaptability to modern techniques.	Proposed by experts	0.690
	4. Design of course structure based on job requirements.	Proposed by experts	0.644
	5. Problem solving skills.	Owlia and Aspinwall(1998)	0.625
	6. Sense of social obligation.	Proposed by experts	0.556
Responsiveness (α = 0.752)	7. Prompt service at service departments.	Proposed by experts	0.856
	8. Courteousness and willing to help.	Owlia and Aspinwall(1998),	0.739
	9. Cleanliness, orderliness, systematic and methodical.	Proposed by experts	0.695
	10. Transparency of official procedure, norms and rules.	Scheerens and Bosker(1997)	0.556
	11. Adequate facilities/infrastructure to render service.	Proposed by experts	0.533
Physical Facilities	12. Well equipped laboratories with modern facilities.	Redfern(1980), Horne and Pierce(1996) ,Owlia and Aspinwall(1998)	0.762
	13. Comprehensive learning resources.	Proposed by experts	0.752

(α = 0.909)	14. Academic, residential and recreational facilities.	Proposed by experts	0.750
	15. Aesthetic views of facilities.	Proposed by experts	0.658
	16.Training in a well equipped communication laboratory	Proposed by experts	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 (α = 0.897)	19.Encouragement for sports games and cultural activities	Proposed by experts	0.874
	20. Enhancement of knowledge.	Proposed by experts	0.809
	21. Adherence to schedule.	Tomlinson(1980)	0.753
	22. Extra academic activities.	Proposed by experts	0.602
	23. Recognition of the students.	Trethowan(1987)	0.527
Academics (α = 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.	Proposed by experts	0.548

4.0 APPLICATION OF NEURAL NETWORKS

Human decision-making process can be modeled using neural networks as it has the capability to predict an output, classify a given set of inputs into different groups (known as the pattern recognition), and incorporate heuristic criteria [15]. As 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 modeling of a customer's decision making [16]. For effective evaluation and measurement of quality, neural networks based on back propagation algorithm are widely used to model qualitative and intangible aspects of different service sectors. Hoefer and Gould [7] used a neural approach to predict students' academic performance in business programme whereas Nordmann and Luxhoj [8] applied for forecasting of service problems in aircraft structural component grouping. Tam and Kiang [9] applied a neural approach for predicting failures in banking sector. In this study, four neural networks models have been designed for the analysis and evaluation of service quality in education sector with the inputs like customer expectations, perceptions and the gaps.

4.1 Network Parameters

The responses obtained from different stakeholders for twenty eight items in regard to perceptions and expectations pertaining to TES are used to measure the quality through application of back propagation algorithm of neural networks. The back propagation module of a neural network package NeuNet Pro version 2.3 is used for the training and testing of survey data. The network parameters are taken as follows: Input layer with 28 nodes, one hidden layer with 11 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.
During the training phase, learning rate less than 0.1 and momentum parameter near to zero are considered. Seventy five percent of data for each stakeholder are taken for training and the rest data are used for testing. The numbers of correct outputs are noted till the root mean square error (RMSE) is minimized to a reasonable value.

4.2 Design of Models

This study uses four models such as perception minus expectation gap (P-E gap), expectation minus perception gap (E-P gap), perception-only (P-only), and expectation and perception (E&P) models to predict service quality.

Model-I (P-E gap model): In this network model, the input is defined using the traditional SERVQUAL-based gap that means perceptions of customers minus the expectations [17]. This resulted in twenty eight input nodes, a hidden layer and an output layer consists of one node representing the overall evaluation of service quality. Using the training sample (75% data), the network is run till root mean square error (RMSE) is minimized. Then, the network is tested with test data (25% data) and finally the percentage of correct outputs is noted.

Model-II (P-only model): The use of perception and expectation gap raised concern among the researchers about its low reliability and poor inter-factor correlations [18]. It is argued that perceptions of the customer are more important than the gap between their perceptions and expectations. Therefore, a new service quality measuring instrument known as 'SEVPERF' considering only the perceptions of the customers is suggested. In this model, customer perceptions-only are

used as input to the network. The perception data are trained to obtain the minimum root mean square error and finally, tested to get the percentage of correct output.

Model-III (E-P gap model): Generally, it is assumed that most customers enter a service situation with some expectations [19]. These expectations are formed either by previous experiences of the same or similar service, or simply expectations generated by customer independently. So, customer usually 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. A positive E-P score implies that customer expectations are not met whereas a negative score in this gap indicates the delighted customer. The values of gap for the twenty eight items of EduQUAL are used as the input data for this network. The training and testing of the E-P data are carried out in a similar fashion as mentioned earlier.

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 [19]. Therefore, the interactions of expectations and perceptions independently may be considered without a predefined relationship between them. In this case, input layer of this neural network model consists of fifty six nodes-twenty eight input data for expectations and twenty eight for perceptions. The training and testing of data are carried out in a similar fashion.

4.3 Performance of the Models

The parameters used in all four models are shown in Table 2. The learning parameters for the training and testing of the survey data varies from 0.07 to 0.1 and the momentum parameter approaches to zero value (0.01 to 0.03). The number of cycles varies in different models for various stakeholders. The value ranges from 18680 to 293380 for students whereas it ranges from 3730 to 30855 for alumni. But for parents and recruiters, the training cycles ranges from 2760 to 7975. The percentage of correct output is decided by considering the lowest root mean square error (RMSE). 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. A model is said to perform best when percentage of correct outputs is higher for same RMS value. Considering the maximum percentage of correct outputs with minimum RMS error, P-E gap model is found to be the best model for predicting correct output for all the stakeholders.

As a matter of fact, the comparative study of four models suggests that P-E model has better predictive power for all the important stakeholders in a TES. 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 overemphasize on expectations but judge the quality of education in an indirect way from their wards and job seekers. It is worthy to mention that E & P is the worst among all models for all stakeholders considered in this study. Since statistical evidence also favors EduQUAL, it may be used for predicting service quality in TES and identifying deficiency in the system according to four important stakeholders of the system. Sensitivity analysis of the best model will help to identify the deficiency in the system.

Table 3: 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	293380	0.21	77*
	P-only	0.09	0.03	18680	0.22	62
	E-P Gap	0.08	0.01	461380	0.25	69
	E & P	0.09	0.02	379195	0.21	69
Alumni	P-E Gap	0.07	0.01	21775	0.15	90*
	P-only	0.09	0.03	30855	0.15	60
	E-P Gap	0.08	0.01	17725	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

Note: * indicate the highest percentage of correct output

4.4 Sensitivity Analysis

In order to find the robustness of the proposed model, 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 per cent (±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 per cent and the current input decreased by 10 per cent. The scaled change in output is given by:

$$scaled\ \ change\ \ in\ output = \frac{Scaled\ \ output\ \ for\ 10\%\ increase\ \ in\ input - scaled\ \ output\ \ for\ 10\%\ decrease\ \ in\ input}{2} \quad \ldots.(2)$$

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 4).

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. Logically, net effect of change in input (gap) results in negative score for average scaled change in output. About 50 to 60 percent of inputs 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.

It can be observed from the Tables 4 that there are six common items rated negative score by all stakeholders. The six 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 effect on service quality and the policy makers of the TES must focus on these areas for improving satisfaction level of potential stakeholders. 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.

Table 4: 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.

5.0 CONCLUSIONS

In the first part of this research 256 survey articles published between 1994 and 2004 in various types of journals are analyzed. Twenty key factors have been considered from the core concepts of TQM. The analysis shows that some of the critical factors such as leadership and top management commitment, customer focus and satisfaction, process management and control, training and employees participation have been given prominent coverage whereas critical factors such as supplier management, employees appraisal, rewards and recognition, quality culture, quality system, zero defect, benchmarking and impact on society are given relatively less coverage. It is also observed that the implementation of TQM in service sector is only 21%.

The second part of this paper is to provides a systematic integrated approach for modeling customer evaluation of service quality applied to technical education. EduQUAL, a survey based model has been developed specially 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 in this study. The responses obtained from stakeholders for the individual items EduQUAL as inputs to the different neural network models. It has been observed that P-E gap model is the best model for predicting the service quality for all stakeholders considered in this study. The study reconfirms that traditional P-E gap for defining quality outperforms other gap models.

The final step in our study demonstrates the use of sensitivity analysis of the best model to identify the deficient items suggested by all four stakeholders for providing guidelines to the policy makers. The areas where the improvements in the service is required for a TES are 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). Although this study demonstrates the methodology for modeling customer evaluation of service quality in education sector at an aggregate level, the approach is quite general and can be applied to any specific organization considering the above discussed methodology. The neural network models developed in this study are seemed to be adequate for predicting the evaluation of customers. However, sensitivity analysis of neural network models indicates that the models are not robust enough. Therefore, future research in this direction may be carried out.

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