11. GRAPH THEORY APPROACH FOR TQM EVALUATION OF TECHNICAL INSTITUTIONS

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Abstract

Technical education in India encompasses various programs in Engineering, Management, Architecture, Pharmacy, Town Planning, Applied Arts, Technology and Crafts at different levels. As the enrollments are increasing at a fast pace, new programs are fast emerging. The competition among the various technical institutes becomes fierce as all the educational institutes are contesting for position or rank in the marketplace. Institutions are frequently turning to quality to distinguish themselves from their counterparts. Presently bodies responsible for technical education in India have already started assessment of engineering and technological institutes. All India Council for Technical Education (AICTE) is evaluating procedure for accreditation. Accreditation is a process to determine whether the institution meets the threshold quality criteria and satisfy the minimum educational criteria. However, the regulatory mechanisms of AICTE are not sufficient alone to ensure quality of educational institutes. The assessment of the total system in terms of designing of various programmes and delivery of the same, customer satisfaction, addressing research and service quality could lead to quality education. With multiple challenges like increasing tuition fees, ever increasing enrolments, changing profile of the students etc. this research paper uses Graph theory approach to develop a framework for TQM evaluation of technical institutes. The framework prioritizes the interest and the requirements of various stakeholders in TQM evaluation.

Keywords: *Technical institutions, Curriculum, Total Quality Management, Graph Theory, India.*

Introduction and need of TQM in technical education

According to Feigenbaum (1994), the quality of education means the products and services is determined in such a way that managers, teachers, workers, engineers and economists think, act and make decisions about quality. Helms and Key (1994) suggested that TQM principles are more compatible with higher education than many existing management system. Seymour (1992) and Ellis (1993) expressed their opinion that due to consumerism, customers demand higher quality at a lower cost. Lewis and Smith (1994) felt that unhappy customers and low employee morale is increasingly becoming a problem for most of the educational institutes. According to Engelkemeyer (1993) the shortcoming to the present education system lies in poor teaching incoherent curricula, excessive cost of education and inefficient bureaucracies.

Burkhalter (1994) discussed that TQM involves all the three stakeholders including employees, customers and suppliers and

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strategically integrates all of them to achieve quality education. Mukherjee (1995) discussed in his research paper that TQM encompasses value to cost, value to price and error free performance, which are primary, concerns to the producers, customers and society at large respectively. Walsh et al. (2002) suggested that TQM is customer focused and revolves around the concept of customer satisfaction. Ho and Wearn (1995) developed the model Higher Education TQM Excellence Model (HETQMEX) based on service quality and demonstrates the advantages of TQM and its effectiveness. Michael and Sower (1997) presented a comprehensive model for implementing TQM in higher education. Thakkar et al. (2006) presented QFD approach and Force Field technique to implement TQM in self financed technical institutions.

Literature Review

The introduction to Total Quality Management (TQM) has proved its worth in higher education (Lewis and Smith 1994, Vazzana and Winter 1997, Hughey 1997, Seymour 1992, Thakkar et al. 2006).As defined by ISO9004 (BSI, 1993), TQM is the management philosophy and company practices which aim to improve the human and material resources of an organization in the most effective way to achieve the objectives of the organization. As discussed by Ho and Wearn (1996), higher education needs the TQM philosophy like any other business.

Witcher (1990) defined the word TQM into three terms. 'Total' implies every person in the organization is involved including customer and supplier. 'Quality' means requirement of the customers is satisfied and 'Management' signifies that senior executives are committed to the organization. Taylor and Hill (1992) defined TQM as a customer focused process, which requires continuous improvement and satisfying the customer's expectations. William (1993) focused on two dimensions of TQM. One dimension of TQM is to keep the customers happy, cutting down the wastage and to increase the productivity. On the other hand it is a mean of making better people, develop good manners and provide with a moral education. Harris (1994) explained three generic approaches to TQM. The first approach is the customer-focused approach where the service the rendered to the students staff training and development. Secondly it is concerned with the value of staffs and their enhancement of their contribution. Finally, a service agreement that focus to ensure the educational process. Burkhalter (1994) integrated all the stakeholders including employees, customers and funding bodies to express TQM in education. Mukherjee (1995) included parameters like value to price, value to cost and error free performance, which are concern for the customers, producers and the society respectively. Dahlgaard et al. (1995) defined TQM as an educational culture characterized by increased customer satisfaction through continuous improvement in which all employees and students actively participate. Anjard (1995) defined TQM consists of competitive strategy, a technology to produce goods and services and a way to manage the organization. Mohanty and Behera (1996) suggested that TQM requires an understanding of unique characteristics of service operations, roles of service providers and service clients and application of appropriate quality control concepts, tools and techniques. Since TQM underline the involvement of the whole organization, the people who are working in the organization, the infrastructure facilities and the activities going in the organization affect it. Hittman (1993) included leadership, human resource utilization and elimination of unnecessary violation as major principles of TQM. According to Schaffer (1991), leadership is not sufficient, as it needs the involvement of teams in the outcomes.

Rubach (1994) showed that 415 educational institutes in the USA have implemented quality improvement practices in their system, Willmott (1995) reported that the Academic Audit Unit (AAU), an agency whose mandate is quality

assurance in education in U.K. Entin (1993), Kolesar (1994), Likins (1993), Mc Neil (1993), Mahoney et al. (1993), Pickett (1993) reported TQM implementation programmes at various universities which include Boston, Columbia, Lehigh, Northern Arizona and Tennessee. As per the discussion of Harris (1994) TQM has three generic approaches to education. First a customer-oriented approach where the focus is rendered on service provided to students, secondly, the staff focused approach where an emphasis is given on staff development and their enhancement. Finally a focus on service agreement, which helps in conformation to specification.

Technical Education in India

The history of technical education dates back a century and there has been a tremendous growth in the number of technical institutes and its intake. India accounts for third largest science and technology manpower in the world. The rapid developments in the field of technology have radically transformed the socio- economic environment at the national level as well as globally.

As per Human Resource Development annual report in 2003-04, the number of technical institutions and the students' intake of the same are reflected in Table I. (Refer page No. 106)

At the time when the country is liberalizing economy and entering the global market, there is a stringent need to stress quality in technical education. As on today, Technical and Vocational Education Training (TVET) in India is one of the biggest systems in the world with more than 5,000 institutions offering programs at various levels (Bhattacharya, 2002). Technical education is an important facilitator in the growth of economy. It is estimated that 50% of economic development is attributed to technology development globally (Wadhwa et al. 2005). Government of India through All India Council for Technical Education (AICTE) is encouraging in the creation of more facilities for technical education and training. Despite the continuous growth of technical education, the status of technical education is gradually going down in terms of quality and standards.

Presently bodies responsible for technical education have already started assessment of engineering and technological institutes. All India Council for Technical Education (AICTE) is evaluating procedure for accreditation. Accreditation is a process to determine whether the institution meets the threshold quality criteria and satisfy the minimum educational criteria. It only recognizes the quality and does not promote quality.

This paper tries to evaluate the TQM practices of various technical institutes. The obtained TQM index would help to evaluate the institutes and ranking them. This would strengthen the existing quality practice and it would also help the policy makers to take appropriate decision regarding quality development of the institutes. The present study would also give a dimension to ranking of the institutes.

Selection of Variables

'Quality' in general is defined as the ability of a product to satisfy the requirements of the customers. However, 'Quality' is acceptable in education if the customers are satisfied with the service provided to them by the institution.

Existing literature reveals the application of TQM in curriculum development. Froiland (1993), Kendrick (1993) and Barrier (1993) conducted an intensive research to introduce TQM courses into university curricula. Hebert et al. (1995) found a significant correlation between the perceptions of external pressure to adopt TQM and the integration of TQM subject matter into curriculum. Kleindorfer (1994) integrated TQM for curricular innovation. Divoky and Taylor (1996) suggested TQM concepts yield a clearer picture of what is curriculum currently providing and it also helps to evaluate

an educational curriculum. Koch and Fisher (1998) acknowledged the importance of TQM because it has the potential to release urgently needed resources for other important tasks within the institution to increase the students' satisfaction.

Summing the views of De Cosmo et al. (1991), Edwell (1993), Green (1994) and Taylor and Hill (1992), TQM should satisfy the external customers such as potential employers, parents with standard of graduates whereas the internal customers should be satisfied with the teaching and learning process. Coate (1999) suggested that top management and teamwork are critical factors for successful TQM implementation. Leffel et al. (1991) admitted that TQM develops the leadership towards a shared vision and shared values. Heverly (1992), Sherr and Lozier (1991) emphasized on customer satisfaction to define TQM in an educational institute. They also pointed out that educational institutions have turned to TQM for many reasons that businesses have instituted quality programmes. The work by Meirovich and Romar (2006) discussed the role of faculty in TQM environment in educational institute. Barnard (1999) stated the purpose of the education is to provide a learning environment that supports the mission of excellence in education. Clearly the role of infrastructure is also important in TQM environment.

Hebert (1995), Billing (1996), Morris and Haigh (1996) emphasized on application of TQM principles to university administration. They found that the focus of TQM is evident on nonacademic side of the institutions. Based on the work of Coate (1990), Likins (1993), Solomon (1993) and McNeil (1993) TQM acts as a bridge between the faculty and administration to the advancement of the institution. Stuelpnagel (1988), Swift (1996), Kanji and Tambi (1999), Moreland and Clark (1998) and Hughes et al. (2000) in their respective studies focused on benefits of TQM in policy making and administrative functions.

The various critical factors of a technical institute to implement TQM are based on the available literature reviews for this study. The parameters are exhibited in Table II and are considered for the further analysis.

(Refer page no. 106)

The relationship between these parameters and the desired TQM environment is depicted below in Figure I. (Refer page no. 109)

The Ishikawa diagram (Figure 1) shows the relation between the parameters and desired TQM environment. The objective of the paper is to develop a model using inheritance and interactions among factors identified to have a net affect on the TQM environment in quantitative terms. There exists relative importance between theses attributes in both directions. Similarly, the attributes considered for the present study are important for the success of TQM in any institutions. Therefore the interrelations can be represented among other attributes. A TQM performance evaluation attribute digraph is developed based on the above and is shown in Figure 2. (Refer page no. 109)

Graph Theory and Matrix Approach

Graph theoretic approach is a systematic and logical approach that has been applied in various disciplines to make and analyze systems (Gandhi and Agrawal, 1996). It is a versatile tool that has been used in various applications. The graph theory methodology starts from where conventional representation end. Conventional methodologies like flow diagram, schematic representation, block diagrams etc are not suitable for any mathematical analyses and are only used for graphical display or visualization of relationships. However, graph theory is useful in analyzing the interactions or interrelation of various factors mathematically (Grover et al. 2005).

A graph G = (V, E) consists of a set of objects $V= \{v_1, v_2, \ldots\}$ called vertices and another

set E= $\{e_1, e_2, \ldots\}$whose elements are called edges. The vertices v_i and v_j associated with edge e_k are called end vertices of e_k. The most common representation of a graph is by means of a diagram in which the vertices are represented as points and each edge as a line segment joining its end vertices. The nodes (Ti's) represent the critical factors and edges represent the interaction among the factors. Ti indicates the inheritance of the factors and r_{ij} is represented as a directed edge from node i to node j. To demonstrate the TQM digraph, the five critical parameters are taken into consideration i.e. Infrastructure (T_1), Faculty (T_2), and Curriculum (T_3), Stockholder's satisfaction (T_4) and Systems and Policies (T_5). In applying TQM concepts to academia, the customer-supplier relationship refers to the relationship between the institutions and faculty (supplier) and corporate recruiters (customers) of technical graduates/post graduates; a process focus refers to the emphasis on the curriculum and the student's educational experience both in and outside, the classroom; change in the culture of the organization refers to abandoning typical ideas about curriculum development as discussed by Ferrin et al (2001). Customer satisfaction, customer orientation and customer focus are some of the basic building blocks of TQM philosophy. For continuous improvement, it is absolutely important to understand the needs of the various stakeholders associated in the system. To achieve this, the stakeholders' involvement becomes necessary in a TQM environment. For a long-term association with the stakeholders, the institutions must rely on feedback mechanism for the potential stakeholders. This in turn is reflected in curriculum development, infrastructures, development of the employees provided by the institution.

Based on their inter dependencies, the corresponding digraph is shown in Figure 2.A directed edge from T1 to T2, T3, T4 and T5 indicates the interaction of infrastructure to faculty, curriculum, stakeholders' satisfaction and policies. The infrastructure has an impact on faculty in terms of teaching and research; stakeholders expect an infrastructure like books available in the library, sets of equipments etc. The other two factors like overall working culture, designing of the curriculum are also dependent on infrastructure.

A directed edge from T2 to T1, T3, T4 and T5 strengthens the role of employee. The involvement of the employee to start a new venture, target a new standards, their skills and motivation to satisfy the stakeholders could boost the TQM environment in an institution.

A directed edge from T3 to other four nodes indicates that feedback mechanism can bring a lot of changes to customer's needs. This helps the management to take right steps towards the TQM of the organization. The effectiveness of curriculum is not only within the profession but also within society at large. The need for a curriculum focus will not be solved by selected groups of educators working independently but will only succeed when the profession as a whole understands that a united approach to technology education is essential for a viable field of study (Wicklein, 1997). Divoky and Taylor (1996) suggested a "framework based on TQM concepts, which can be used to examine and evaluate an educational curriculum...[yield] a clearer picture of what the curriculum is currently providing and those areas where focused change may be needed."

The directed edges from T4 show that it is a customer driven market where the customers are given the utmost importance in the system. It helps the authority and management for measuring what they value by involving, projecting, invalidating and confirming the customer's value. It also helps the management to stay close to its customers.

Similarly, the systems and policies of the institution help in the overall growth of the institution. A fair and transparent system encourages faculty to work with dedication;

maintain a long-term relation with stakeholders; to develop an apt curriculum and having an infrastructure helps in building TQM environment within the institution.

The graphical representation of factors given through the digraph is suitable for visual analysis. However, it becomes complex when a number of nodes in a given case increase. To overcome this limitation, the digraph is represented in a matrix form.

Methodology

A methodology for the selection of best performing organization is explained on the basis of digraph and matrix method. The main steps of the methodology are:

1) Identify the performance evaluation attributes (i.e. A_1, A_2, A_3...A_N) for the given institution. Also consider relative importance among the attributes. Obtain the value of the attributes (E_i)

2) Develop the digraph considering the identified attributes and their relative importance. The number of nodes to be equal to the number of attributes considered in step 1. The edges and directions will be decided based on the interrelations among the attributes.

3) Develop the matrix for the diagraph. This will be MxM matrix with diagonal elements as E_i's and off diagonal elements as r_{ij}'s.

4) Obtain the function for the matrix on the lines of expression (1).

5) Substitute the values of E_i and r_{ij}, obtained in step 1, in expression (4) to evaluate TQM for the institution to be evaluated.

6) Arrange the institutions in the descending order of the TQM. As the terms are positive in nature, therefore the higher value of T_i's and r_{ij}'s will result in a higher value of TQM index. This is an indication of more TQM conductive environment. This value is used for comparing and analyzing similar institutions in terms of effective use of factors. This may be also used for self-analysis to improve the TQM enabled situation in an institution.

The interdependencies and overall impact of tangible and intangible parameters on TQM environment is discussed in this paper using a mathematical model by applying graph theory. Matrix representation of the attributes diagraph gives its one to one representation. The order of the matrix is 5x5 and considers the presence of attributes (i.e. E_i) and their relative importance (i.e. r_{ij}). This matrix is represented as:

$$A=\begin{array}{lccccc} \textbf{Attributes} & \textbf{IN} & \textbf{CU} & \textbf{SPO} & \textbf{SS} & \textbf{FA} \\ \textbf{IN} & E_1 & r_{12} & r_{13} & r_{14} & r_{15} \\ \textbf{CU} & r_{21} & E_2 & r_{23} & r_{24} & r_{25} \\ \textbf{SPO} & r_{31} & r_{32} & E_3 & r_{34} & r_{35} \\ \textbf{SS} & r_{41} & r_{42} & r_{43} & E_4 & r_{45} \\ \textbf{FA} & r_{51} & r_{52} & r_{53} & r_{54} & E_5 \end{array}$$

The diagonal elements refer to the inheritance of factors and off-diagonals elements refer to interaction among factors. The row represents inheritance of a factor and its influence on other factors. Similarly, the column represents the inheritance of factor and its dependency on other factors. E_i is the value of its attribute represented by nodes and r_{ij} is the relative importance of i^{th} attribute over j^{th} represented by the edge r_{ij}. Permanent of this matrix A, i.e. per (A) is a standard matrix function and is used in combination mathematics (Rao, 2000).

The permanent function is obtained in a similar manner as its determinant. A negative sign appears in the calculation of determinant while in permanent positive sign reduce these negative signs. This computational possesses result in a multinomial form as expressed in Equation (1).

Permanent of the matrix is written as per Jurkat and Ryser (1966) formula as:

$$\text{Per (A)} = \text{Per (B)} = \prod_{a=1}^{M} + \sum\sum\sum\Lambda\ \sum (r_{ij}) E_l E_k \Lambda\ E_m + \sum\sum\sum\Lambda\ \sum$$

$$(r_{ij} r_{ji}) E_k E_l \Lambda\ E_m + \sum_i \sum_j \sum_k \Lambda\ \sum_m (r_{ij} r_{jk} r_{kl} + r_{ik} r_{kj} r_{ji}) E_l E_m \Lambda\ E_M \qquad \ldots (1)$$

$$+ \left\{ \sum_i \sum_j \sum_k \Lambda\ \sum_M (r_{ij} r_{ji})(r_{kl} r_{lk}) E_m E_n \Lambda\ E_M + \left[\sum_i \sum_j \sum_k \Lambda\ \sum_M (r_{ij} r_{jk} r_{kl} r_{li} + r_{il} r_{lk} r_{kl} r_{ji}) E_m E_n \Lambda\ E_M \right] \right.$$

$$\left. + \left\{ \left[\sum_i \sum_j \sum_k \Lambda\ \sum_M (r_{ij} r_{ji})(r_{kl} r_{lm} r_{mk} + r_{km} r_{ml} r_{lk}) E_n E_o \Lambda\ E_M \right] + \right. \right.$$

$$\left. \left. \left[\sum_i \sum_j \sum_k \Lambda\ \sum_M (r_{ij} r_{jk} r_{kl} r_{lm} r_{mi} + r_{im} r_{ml} r_{lk} r_{kj} r_{ji}) E_n E_o \Lambda\ E_M \right] \right\} \right\}$$

The permanent of the matrix A is a mathematical expression in symbolic form. It estimates the TQM environment in an institute. The above expression has 5! terms. Each term is useful for TQM expert as each term serves as a test for the effectiveness of the relevant group. The physical significance of various grouping is explained as follows:

- The first term (grouping) represents a set of N unconnected TQM elements i.e. E_1, $E_2 \ldots E_N$
- The second grouping is absent in the absence of self-loops.
- Each term of the third grouping represents a set of two element TQM loops (i.e. and r_{ji}) and the TQM measure of the remaining N-2

unconnected elements.

- Each term of the fourth grouping represents a set of three-element TQM loops (r_{ij}, r_{jk}, r_{kl} or its pair r_{ik}, r_{kj}, r_{ji}) and the TQM measure of the remaining N-3 unconnected elements.
- The fifth grouping contains two subgroups. The terms of the first sub-grouping consist of two-element TQM loops (i.e. r_{ij}, r_{ji} and r_{kl} r_{lk}) and TQM component (E_m). The terms of the second grouping are a product of four element TQM loops (i.e. r_{ij}, r_{jk} r_{kl} r_{li}) or its pair (i.e. r_{il}, r_{lk}, r_{kj}, r_{ji}) and TQM component (i.e. E_m).
- The terms of the sixth grouping are also arranged in two sub-groupings. The terms of the first sub-groupings are a product of a two-element TQM loop (i.e. r_{ij} r_{ji}) and a three element TQM loop (i.e. r_{kl}, r_{lm}, r_{mk}) or its pair (i.e. r_{km} ,r_{ml}, r_{lk}). The second sub-grouping consists of a five-component TQM loop (i.e. r_{ij}, r_{jk}, r_{kl}, r_{lm}, r_{mi}) or its pair (r_{im},r_{ml} ,r_{lk} ,r_{kj}, r_{ji}).

Quantification of E_i's and r_{ij}'s

The quality measure of the elements is evaluated and the graph theoretic approach is applied in each system. The values of the inheritance are given in Table III.

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Quantification of r_{ij}'s i.e. off-diagonal elements representing interdependencies, are to be assigned numerical values. The dependence between the elements at system level cannot be measured directly. However, experts can assign values through proper interpretation. The relative importance between two attributes (i.e. r_{ij}) is also assigned value on the scale of 0-10. The relative importance r_{ij} implies the degree of dependence of j^{th} factor on i^{th} factor in terms of relative importance for the given institution. The relative importance between i,j and j,i is distributed on the scale of 0-10 is defined as

$$r_{ji} = S - r_{ij} \qquad K\,(2)$$

It means that a scale is adopted (0 to S) on which the relative importance values are compared and is given in Table IV.

(Refer page no. 107)

Illustrative Example:

For demonstration of the proposed methodology, five technical institutions are taken for the study. For determining the TQM index, the values of the diagonal elements are calculated by using the graph theory methodology. The values of Ei's are exhibited in Table V. These values were gathered as per the questionnaire.

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The responses were converted on a scale of 1-9. The values were normalized by using Lagranges's interpolation formula and are exhibited in Table VI.

(Refer page no. 108)

To determine the interactions, existing literature review was considered and appropriate relative importance is explained in Table VII.

(Refer page no. 108)

rij represents degree of dependence of j^{th} factor on i^{th} factor. For example, r_{12} has a numerical value 6 and it represents the degree of dependence of Faculty (FA) on Infrastructure (IN). However, r_{21} has a numerical value of 4, which was calculated as per the expression given in Equation (2). This value signifies the degree of dependence of Infrastructure (IN) on Faculty (FA). The interdependencies are arranged in Table VII. The relative values are assigned as per the perception of TQM evaluation available in the literature; various institutions can have their own perception to decide the relative importance among the TQM attributes.

Result

The numerical values of TQM index are calculated as per the expression given in Equation (2).

Per (TQM Matrix) =

$$\prod_{i=1}^{5} E_i + \sum_i \sum_j \sum_k \sum_l \sum_m (r_{ij} r_{ji}) E_k E_l E_m + E_i E_{j_j} E_k E_l E_m (r_{ij} r_{jk} r_{ki} + r_{ik} r_{kj} r_{ji}) E_l E_m$$

$$\left\{ \sum_i \sum_j \sum_k \sum_l \sum_m (r_{ij} r_{ji})(r_{kl} r_{lk}) E_m + \sum \sum \sum \sum \sum (r_{ij} r_{jk} r_{kl} r_{li} + r_{il} r_{ik} r_{kj} r_{ji}) E_m \right\}$$

$$\Lambda (2)$$

$$\left\{ \sum_i \sum_j \sum_k \sum_l \sum_m (r_{ij} r_{ji})(r_{kl} r_{lm} r_{mk} + r_{km} r_{ml} r_{lk}) + \sum_i \sum_j \sum_k \sum_l \sum_m (r_{ij} r_{jk} r_{kl} r_{lm} r_{mi} + r_{im} r_{ml} r_{lk} r_{kj} r_{ji}) \right\}$$

institution and is exhibited in Table VIII.

(Refer page no. 108)

As it is evident from the Table VIII, the TQM index, the second institution tops the list followed by fifth, third, fourth and first institution. This indicates that the TQM performance and TQM has been implemented in the best way in the second institution.

Discussion:

This paper tries to evaluate the unique contributions of TQM towards technical education. The various inputs and outputs involved in the system are different from the industry sector. Unlike industries, educational institutions are likely to face enormous variability in terms of quality of incoming students. Because of the increase in the number of colleges, the colleges are confronted with the problem of getting the quality standard of students. Likewise, it is equally difficult to maintain the standard for the output. In industries, it is relatively easier to satisfy its customers; however, in education sector, there are numerous customers like students, prospective employers, parents, alumni, society at large etc. It is a difficult job to prioritize their interests and requirements. The curriculum is one of the many factors that affect the academic performance of the students. However, the evaluation of the students' performance is also a challenging task.

The parameters considered in the present context are selected after a careful analysis of the available literature. Infrastructure or the campus facilities play a significance role in TQM evaluation of the institution. It helps to improve the overall learning of the students. An excellent infrastructure and physical facilities in the campus also affect the other stakeholders. Tangible parameters in teaching like college buildings, laboratories, library, auditorium plays an important role in the TQM evaluation as it involves stakeholders like faculty and non-

teaching staffs in the process. Some support systems like hostel accommodation, transportation facilities, sports complex adds an additional dimension in the overall learning of students. Therefore, the various stakeholders complement each other in the learning process.

The role of faculty or the importance of expert skill to transfer the knowledge to the students is another parameter in the TQM evaluation. Faculty acts like a catalyst between the academia and the industry. The commitment level of the faculty and their course delivery together creates an impact on the institution. Applying teaching skills in delivery of the course content, rich industry experience in knowledge sharing, research and innovation in academics include a commitment for both the faculty and industry. A long term association and loyalty helps in creating a TQM environment.

Systems and policies of the institutions lead to a congenial learning environment for its stakeholders. A positive attitude and transparent system acts like a buttress towards achieving a TQM environment. Transparency is evaluation, timely assessment and declaration of the result, fees charged from the students, facilities provided to the faculty members like providing training program provides motivation to all the stakeholders. Developing employees in terms training and education contributes in the field of knowledge and skills. The advantage of focussing on intangible parameters like quality issues gradually lead to overall TQM environment of the institution.

Curriculum acts like bridge between the academic knowledge and the requirement of the industry. Students want a valuable degree, which would help them to start a professional career. Employers want well-educated and skilled workforce with minimum orientation and training. Institution wants to expand the knowledge and education by emphasizing on curriculum. Involving industry to develop the quality program creates an opportunity of interaction of faculty and employers. Constructive feedback from the students as well as from the industry provides a fair idea of shortcomings in the course, which could be removed from the curriculum, and the quality can be maintained. However, number of industry visits arranged by the institution, number of projects undertaken by the institute increases the effectiveness of the program.

Employee involvement is an important theme of TQM, which aims to involve all the stakeholders for continuous improvement. Customer's orientation in education is an accepted principle by most of the practitioners. To know the need of the customers the institution must stay close to their customers. Using appropriate statistical tools to translate their needs into product design and operations, anticipating their future needs and analyzing their satisfaction would be able to develop the concept of quality philosophy.

Conclusion:

This paper attempts to demonstrate the usefulness of TQM for technical education in India. A quantitative framework of graph theory is developed to support the idea of applying the concept in a systematic way. The present research reported the implementation of TQM in educational settings and examines the feasibility and suitability of such application.

There seems to be little doubt that TQM can produce fruitful results if applied in education sector. Though application of TQM is completely different from industry, there is a vast literature available on application of TQM in education. Industries are mainly concerned about the relationship between customers and suppliers and how to increase the customer satisfaction by improving the services provided by the suppliers. However, in education system, the students, alumni, prospective employers, parents, society share the same characteristics of customers even though they are segregated into internal and external categories.

Establishing quality improvement process and working on them would distinguish them

from traditional practices. After reviewing the existing literature and from the empirical study, it seems feasible and useful to implement the concept of TQM in technical education.

Limitations:

According to Sallis (1993), TQM emphasizes on customer satisfaction that may cause some conflicts within system. The various stakeholders may not agree in the context of their expectation. Though teamwork is an essential requirement in TQM, individual activity like doing research is given importance in the education sector. This is perceived as a personal advancement and recognition within the system. The principles of TQM are to be adopted in the education system carefully.

Table I. Approved Technical Institution in India.

Programmes offered	Number of Approved technical institution in India	Intake of the approved technical institution
Degree		
Engineering & Technology	1265	380803
Pharmacy	320	16410
Hotel Management & Catering Technology	49	2640
Architecture	107	3408
Post Graduation		
MBA	958	71251
MCA	1034	36338
M.E./M.Tech./M. Arch./ M. Pharma.	1727	29357

Table II. Parameters cosidered in the present context

Critical Factors	*Abbreviation used for analysis*
Infrastructure	IN
Systems and Policies	SP
Faculty	FA
Curriculum	CU
Stakeholder's satisfaction	SS

Table III : Qualification of TQM factors

Qualitative Measure of performance evaluation attribute	Attribute Value of TQM performance evaluation (E_i)
Exceptionally Low	1
Very Low	2
Low	3
Below Average	4
Average	5
Above Average	6
High	7
Very High	8
Exceptionally High	9

Table IV : Quantification of interdependence of TQM factors

Sr. No.	Qualitative measure of interdependencies	r_{ij}	$r_{ji} = 10-r_{ij}$
1	Two attributes are of equal importance	5	5
2	One attribute is slightly important over the other	6	4
3	One attribute is average important over the other	7	3
4	One attribute is above the average important over the other	8	2
5	One attribute is highly important over the other	9	1
6	One attribute is exceptionally important over the other	10	0

Table V : Inheritance (E_i's) for various parameters of the institution (collected as per questionnaire in annexure)

Organization	IN	FA	CU	SP	SS
1	29	18	20	14	15
2	35	22	40	18	21
3	37	15	35	20	18
4	40	20	19	17	17
5	30	19	36	22	23

Table VI : Normalized on the scale of 1-9 from the table VI

Organization	IN	FA	CU	SP	SS
1	1	5	1	1	1
2	5	9	9	5	7
3	7	1	8	8	4
4	9	7	1	4	3
5	2	6	8	9	9

Table VII : Interdependences (r_{ij}'s) for parameters of the organization

Attributes	IN	FA	CU	SP	SS
IN	-	6	5	5	6
FA	4	-	7	6	6
CU	5	3	-	7	8
SP	5	4	3	-	6
SS	4	4	2	4	-

Table VIII : The values of the grouping of five institutions

Organization	I	II	III	IV	V_a	V_b	VI_a	VI_b	Total
1	5	0	768	5970	13717	1080	40864	37480	99884
2	14175	0	75900	111070	54569	4200	40864	37480	338258
3	1792	0	32940	73260	44507	3360	40864	37480	234203
4	756	0	16878	90000	37021	2880	40684	37480	225699
5	7776	0	65484	108450	52266	4080	40684	37480	316220

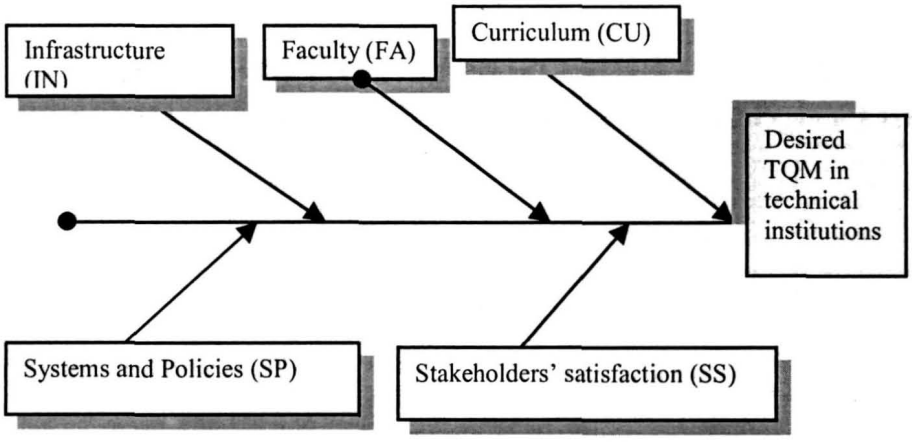

Fig. 1 : Ishikawa diagram of the various factors affecting desired TQM in technical institutions

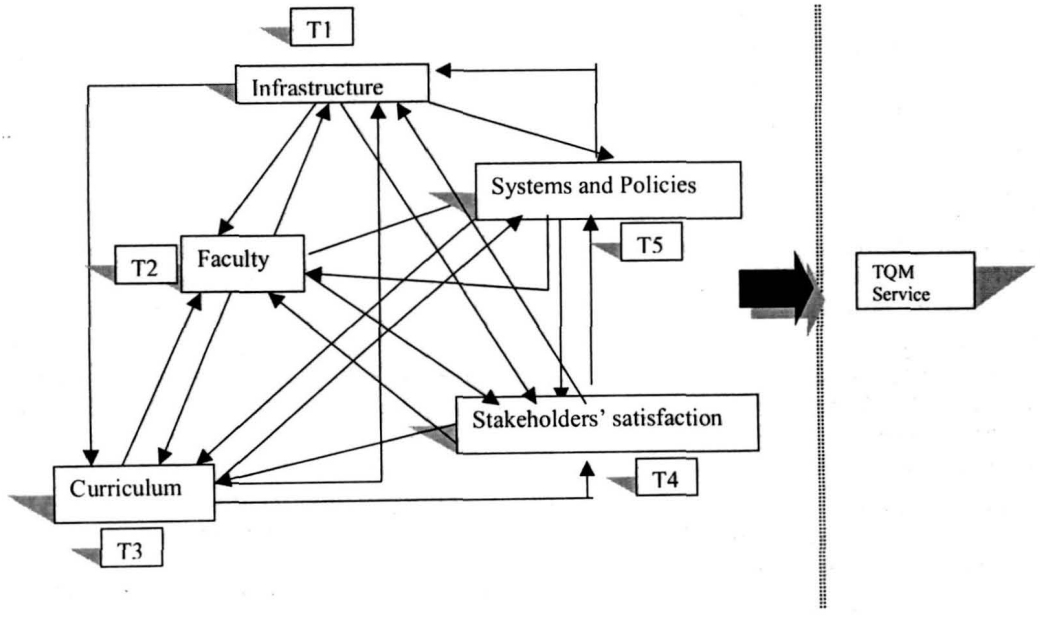

Fig. 2 : Schematic representation of the relationship of one node with other four nodes