
Total Quality Management in Engineering Education in India

With special reference to Punjab and Chandigarh

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India is in a state when it is trying to be a global manufacturing hub and it also trying to develop itself as a knowledge economy with skilled manpower. Ambitious programs like Make in India can be successfully implemented only by having skilled and qualified manpower. For this purpose it is very essential that our engineers, are able to contribute towards the manufacturing processes meeting the global standards. However, while the number of institutions has grown substantially - both in the categories of public and private engineering colleges, there is a concern regarding the quality of education imparted. A Total Quality Management based approach, that has been applied to Higher Education internationally, can provide important pathways in enhancing quality in Engineering Education.

Keywords: Engineering Education, Quality of Education, Total Quality Management

INTRODUCTION

In the last two decades, India has witnessed an eight-fold increase in the number of institutions imparting Engineering Education at the undergraduate level. According to the estimates of the Eleventh Five year plan, the country is expected to be home to a skilled workforce of 500 million by 2022 (Planning Commission, 2007). The Plan also focuses on expansion proposing establishment of 30 new universities. Further, as per the plan, eight new Indian Institute of Technology (IITs), seven new Indian Institute of Management (IIMs), 20 new Indian Institute of Information Technology (IIITs), five new Indian Institutes of Science, two Schools of Planning and Architecture, 10 National Institute of Technology (NITs), 373 new degree colleges and 1000 new polytechnics are to be established (National Knowledge Commission, 2009). A good number of these institutes have already been set up and the rest are under establishment. Between 2009 and 2011, the elite technical institutions recorded a 55 percent increase in seats from 90,513 to 140,000 (Loyalka et al, 2013). The growth in number of non-elite institutions and the seats therein has been much more.

However, there are concerns regarding the quality of Engineering Education imparted. Existing studies point to growing skill gaps resulting not just in unemployment but also in employer dissatisfaction (Latitude Group, 2013). The growth in numbers has

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not been accompanied by corresponding quality standards. Several studies have observed the inadequacies in both quality and quantity of Engineering Education-while a 2005 NASSCOM report foresaw shortage of 500,000 knowledge workers by 2010, the U R Rao Committee has projected that India needs well over 10,000 PhDs and twice as many M Tech degree holders for meeting its Research and Development (R&D) needs (FICCI, 2013). However, commenting on quality, the aforementioned NASSCOM report shows that the multinational companies find only 25 percent of Indian engineers employable in the IT sector. Other studies have also raised concerns that the quality of IT services in specific and the firms in general may stagnate because of the poor quality of technical skills of the of the employees. Consequently, the response from the industry regarding the job preparedness of the engineering graduates has been very poor and about three-quarters of India's technical graduates are considered inadequately skilled and therefore unemployable by India's high-growth global industries (Anand, 2011). It is on such counts that the quality of technical education in India has often been found to be inadequate especially in comparison with the United States. Making such a comparison, scholars have discussed the poor opinion that employers have of the quality of engineering graduates in the BRIC countries concluding that the overall competitiveness of India was nowhere near such countries as the United States (Blom, et al 2011).

The recent and enormous increase in engineering graduates from India makes it important to assess if the quality of such education and the professionals it produces is globally comparable or competitive. This is of interest as countries like India have been producing graduates in technical education from both elite and non-elite institutions resulting in a range of quality. While some of the colleges are recognized as institutes of excellence with impressive faculty and student profile, there are several that do not meet the requisite quality standards.

In this context, a Total Quality Management (TQM) based approach offers interesting possibilities to understand the quality of Engineering Education. Total Quality Management is an approach of managing the whole to achieve excellence. It is defined both as a philosophy and a set of guiding principles that represent the foundation of a continuously improving organization. It is the application of methods and human resources to improve all the processes within an organization so as to enhance present and future efficiency and productivity. The approach, with a focus on stakeholders provides an important lens to look at the important aspects of quality such as communication, leadership and commitment of the management. Customer-orientation, Total stakeholder involvement, Process-centered, integrated systems, Strategic and systematic approach, Continual improvement, Fact-based decision making and Communications. These elements are important components of TQM and represent the fundamental principles on which organizations committed to TQM are expected to operate.

REVIEW OF LITERATURE

Some of the important issues concerning the quality of engineering education in India faces: curriculum and its delivery, low financial allocation per student, inadequate infrastructure, Quality of faculty, number of faculty members per student, management issues pertaining to institutions, limited research resulting in too few publications, student perspective and industry interaction (Loyalka, et al 2013; MHRD, 2011 Carnoy 2013; National Knowledge Commission, 2009).

It is important to note that these concerns are not new. Close to two decades back, Jain et al (2000) in their paper discussing the lacunae in the present technical education system in India based on understanding of the technical education scenario had recommended skill development, with regard to industry-academia interaction, academic audits,

information systems and filling faculty vacancies. However given the similar issue persist till date and in greater magnitude due to sudden increase in the number of colleges, new approaches have become necessary.

Tiwari (2000) in his paper on Total Quality management in Technical Institution had enlisted the main messages from the thought leaders of TQM to set the visions for embedding quality assurance initiatives in technical education.

Achintya and Mishra (2000) in their paper titled quality Assurances in Engineering Education while mapping the trajectory and evolution of Engineering education had also expressed their concerns about the falling quality of such education and steered attention towards the need to address the same. Bhat (2000) in a perspective paper on quality of education in technical institutions identified the teachers as the driving force of Engineering education and focused on creating opportunities of their professional growth. The author identified four phases for ensuring quality standards: 1) Providing the vision, 2) Management Action 3) Increasing participation and 4) Business alignment

Naik (2000) in his paper on internationalisation of higher education also talks about competitiveness of Indian engineers globally. Emphasising the need to upgrade the quality substantially, he emphasises on the need for creating research facilities, incubation centres and technology transfer centres. Comparing the educational scenario of India with that of the developed countries, the author argues that investment in Engineering Education with a focus on research and development while appearing to be expensive, yields significant dividends that can actually propel the growth of the country. He emphasises that such education should not be starved of funds so that India can be a proactive participant in the global knowledge society.

One of the approaches tried has been the Balanced Scorecard (BSC) system. Venkatesh and Datta (2007) based on their review paper discuss the BSC

concept and assess the ways in which it should be applied to higher education programs/ institutions in the Indian context. BSC approach offers an institution to formulate a cascade of measures to translate the mission of knowledge creation, sharing and utilization into a comprehensive, coherent, communicable and mobilizing framework for external stakeholders and for one another. However, in the absence of evidence of the application of BSC to the educational institutional domain in India, it is difficult to comment on its suitability.

While TQM in Engineering Education is not new, many educational institutions in the developed countries follow some or most of the principles without explicitly calling it TQM. Existing studies have indicated the use of TQM perspective for and assessment of the quality of education with specific reference to higher education (Sahney et al, 2004). Research also point to the need for higher quality in Engineering Education and the possibilities that TQM offers in this regard (Mahapatra and Khan, 2006; Sahu et al 2008). While there have been some attempts to use TQM to education in the West (Winn and Green, 1998), such efforts are at a very preliminary stage in India. Also, the existing studies are yet to consider a stakeholder satisfaction oriented approach to Engineering Education.

Given this context, an extensive literature review was carried out focusing on the following five themes -

- Identification of components of TQM for technical education
- Accreditation for Quality Improvement
- Leadership and Management Commitment to Quality
- Stakeholder focus
- Industry interaction

Table 1 presents the summary of the key concepts, authors and key ideas around TQM in Higher Education with specific reference to Engineering Education

Table 1: TQM in Engineering Education: Key Ideas

Concept	Authors	Key ideas
Management approach to Higher Education	Winn and Green, 1998; Sahney et al, 2004; Mahapatra and Khan, 2006; Sahu et al 2008;	Total Quality management approach to Higher Education
Components of TQM	Lagrosen, 2004 Sakhivel and Rajendran, 2005; Begum et al, 2010 Senthilkumar and Arulraj, 2010 Sahu et al, 2013	5-C TQM Model in engineering institutions of India focused on management commitment, course delivery, campus facilities, courtesy and customer feedback and improvement. Identification of 27 components reiterating positive relationship between TQM dimensions and institutional performance
Leadership and Management Commitment	Sohani and Sohani 2011; Ola 2013; Sudha, 2013	Top management has to be involved and provide leadership to the process of quality enhancement
Accreditation	Bhat 2000, Natarajan, 2000; Sudha, 2013; Das et al (2014); Thandapani, 2010	Indicators of accreditation around stakeholders self-evaluation mechanisms for the higher educational institutions.
Stakeholder Engagement	Alridge and Rowley, 1998; Wills and Taylor, 1999; Chua 2004;Khanna, 2012; Masood, 2007; Gulbarga et al, 2012a; Eftthimia , 2006; Sudha, 2013	Need to identify and engage with different set of stakeholders including management, faculty, industry and students
Industry Interaction	Nair and Banerjee, 1982; Bansal and Singh, 2000;Jain, 2000; Murthy, 2002; Gol, 2009; MHRD, 2011; Gulbarga et al, 2012a; Gulbarga et al, 2012b; FICCI, 2013; Loyalka, et al 2013; Carnoy 2013;	Need for greater and regular industry interaction Fellowship and Exchange programmes between industries and technical education institutions Universities as incubators of ideas for the industries with shared research spaces Dynamic curriculum based on changing industry needs
Barriers to TQM Implementation	Grant et al 2002; Talib F, 2011; Brookers and Becket (undated web publication)	Challenges pertaining to the implementation of quality models especially those concerning performance quality Two levels of problems- at the level of Top management with low levels of commitment to high quality and at the level of Human Resources with high attrition of managers Focus of TQM more towards non academic and Managerial functions

Identification of components of TQM for technical education

One of the early studies that attempted to use quality model to Higher Education was carried out by Lagrosen et al (2004) who use student interviews with Swedish and Austrian students to capture their perspective on quality. The researchers used a questionnaire to developed based on in depth interview with students to elicit response from 448 students on components of quality that they considered important. Against these components, the student perspective on what they considered most important for quality was mapped and differences in responses documented across

different groups of students. This elicited that Corporate collaboration, Information and responsiveness, courses offered, internal evaluations, computer facilities and library resources. Though the study was limited in terms of engaging with only students, it elicited important dimension concerning one of the most important stakeholders.

Sakhivel and Rajendran (2005) in their research on the implementation of TQM and students' satisfaction regarding academic performance based on a sample study of students from ISO and non-ISO engineering institutions from South India have looked at developing models of TQM variable for

academic excellence. They study reiterates the 5-C Total Quality Model of academic excellence in engineering institutions of India with a focus on commitment of top management, course delivery, campus facilities, courtesy and customer feedback and improvement. However, it is important to undertake similar research across various categories of institutions.

Begum et al (2010) in an empirical study of total quality management in engineering educational institutions of India explore the management practices in engineering educational institutions in India. Identifying 27 critical factors of quality management, they conclude that there is a positive relationship between TQM dimensions and institutional performance in term of quality of education.

Senthilkumar and Arulraj (2010) in their engagement with quality in higher education with specific reference to placement have collected data comprising six sections covering Teaching Methodology (TM), Environmental Change in Study Factor (ECSF), Disciplinary Measures, Placement, Service Quality, Satisfaction level. Data were collected from final-year students of higher educational institutions across Tamil Nadu. Based on their study, they propose service quality measurement (SQM-HEI) model. Specifically, they emphasize that quality of education depends on the quality of faculty teaching, physical resources and infrastructure and a range of Disciplines that facilitates the creation of a diverse set of students and also improves placement prospects.

Sahu et al (2013) undertake a review of existing literature to identify critical factors that can facilitate use of TQM and other quality enhancement models in education to improve the quality of higher education. Based on their content analysis, they conclude that adoption of TQM in technical universities need a dedicated approach that take into account certain critical factors. These include Repositioning of the Senior Management (with a

focus on vision, commitment, resource allocation, etc), infrastructure including appropriate R&D space, good ambience, libraries and classroom environment; intermittent development and alteration of curriculum with a focus on teaching methodology, student teacher ratio and R&D and technical education, excellence training, development and placements with a focus on skills and related competencies of the students and their communication skills.

Leadership and Top Management Commitment

Based on their study conducted with the objectives of developing a quality based structural framework of education system in higher education in India, Sohani and Sohani, 2011, have engaged in identification, sequencing, categorizing and prioritizing quality characteristics into a systematic model. In doing so the authors have emphasized on the role of the top management. They have discussed that leadership with vision and effective allocation and financial management plays critical role in setting up management system for higher education, leading to overall improvement of quality.

Ola (2013) in his research on Total Quality Management (TQM) and continuous improvement considers TQM as a philosophy seeking to integrate all organizational functions. Using the TQM principles and Baldrige model based on European Federation for Quality Management (EFQM) model of business excellence framework, he emphasizes that top management should be involved in the application of quality and all employees should participate. He also identifies the key principle of TQM as management commitment, employee empowerment, fact based decision making, continuous improvement and customer focus.

Sudha (2013) based on her study with faculty members across Higher Education institution has also reinforced the importance of the commitment of the top management emphasizing on their role in reflection and self-evaluation.

Accreditation for Quality Improvement

Natarajan (2000) in his research on the role of accreditation in promoting quality assurance of technical education emphasized the importance of accreditation and objective parameters on accreditation. In doing this, he proposes to have develop indicators of accreditation around stakeholders, a key focus on the TQM approach. The paper emphasis the significance of accreditation of institutes for promoting the quality assurance of technical education and demonstrating impact through indicators around student, faculty and institutional quality.

Bhat (2000) also focuses on the role of accreditation for ensuring quality in technical education. He emphasises that accreditation helps the stakeholders including parents, students and employers to identify institutions that meet the standard quality indicators. It also plays an important role in terms of benchmarking institutions for upgradation. Finally, it helps to maintain high standards and encourage institutions to move towards excellence through a process of continuous improvement.

Sudha (2013) based on her study involving faculty members of educational institutions emphasizes the importance of self-evaluation mechanisms for the higher educational institutions. She emphasizes that such an evaluation should include the top management, faculty and students, taking into account multiple perspective to arrive at a comprehensive understanding of the performance of the academic institution with regard to quality.

Das et al (2014) in their study on Multi-criteria performance evaluation of Indian technical institutions focus on the performance analysis of seven premier technical institutions under a multi-criteria environment, for which a multi objective decision making model (MOORA method) is explored. Uses quantitative data, institutions are considered as alternatives and measured against six attributes. The paper evaluates the output produced by institutions and compares them against the

resources used in doing the same. They emphasize on the use of methods like MOORA for ranking of institutions and making relative comparisons.

Thandapani et al (2010) in their work on tracing the quality journey across organisations and engineering educational institutions by a comprehensive review of the literature also emphasised on the importance of accreditation for the modern Engineering Educational Institutions (EETs) from the Accreditation Board for Engineering and Technology (ABET)-meeting the required stipulations. This would lay the foundation for more implementation of quality models. The authors emphasise that the industries adopt the ISO 9000 certification for embedding quality in their performance, while the engineering education institutions have focused on accreditation for meeting quality standards. The authors conclude that the Washington accord favours ABET for the standardization of the accreditation process and should be the core function of modern institutions.

Stakeholder Focus

Babai KS, Dharmambal (2000) based on their study on TQM in Stakeholders from Dr Dharmambal Govt Polytechnic, emphasize that the students are the first customers of educational institutions and the way institutions can align their activities to the satisfaction of this customer. Focusing on quality creation, rather than on quality control., they emphasize that the quality creation consciousness and implementation in engineering institutions comes through innovation in curriculum development, staff development, facility development and a focus on personality development of students, continuous improvement, industry interaction and consultancy & research, field work orientation approach to complement library oriented approach. The paper speaks of quality as an organization wide activity which involves all stakeholders

Chua (2004) in her paper titled Perception of Quality in Higher Education discussed the issues of quality

in higher education from a marketing perspective. While looking at quality in higher education from multiple perspective including those of students, parents, faculty members and employers, she focuses on quality from a marketing perspective with a view to understand the needs of the customers of higher education and their perceptions. She uses a Input (Selection of students, entry requirements), process (teaching and learning, content and delivery, professor's knowledge, curriculum, assessments etc) and Output (Financially rewarding job, placement, academic performance). The study elicited that that the different stakeholders: parents, students, members of the faculty and potential / existing employers perceived quality differently. While the parents view quality as relating to input and output, the students perceived quality in terms of educational process including courses and teaching) and outputs. The faculty members demonstrated a comprehensive understanding of quality relating the same to the entire education system. The employers perceived quality in terms of skill sets of the students, focusing on the output aspect.

Aldridge and Rowley (1998) based on their study of the student experience at Edge Hill University College, UK use a questionnaire-based survey. Focused on the experience of the students covering both their personal attributes as well as their feedback on the institution, they propose a theoretical model that emphasizes the need to respond to student dissatisfaction- whether they pertain to individual incidents leading to complaint or more longer term issues. Emphasizing on the issue of quality, they argue that continued perception of poor quality leads to disconfirmation. They further discuss that disaffirmation occurs when student withdraws as an effective member of the educational institutional community. This can both be through formal withdrawal from the institution or manifest in failure. Disaffected students also continue to remain in the institution while performing poorly, perceiving a lack of other options.

Willis and Taylor (1999) in their study to gauge employer's perspective on quality based on data collected from business organizations emphasize that the performance of the employees is not used by the businesses to arrive at decisions regarding the quality of institutions of higher education. Rather, the emphasis in the work setting is on the kind of skills that are required by them. The authors emphasize the need to extend the TQM principles to teaching and learning processes, administrative and operational processes of the colleges.

Khanna (2012) based on his research using a qualitative approach to improvement in technical education using Total Quality Management (TQM) concept has studied the engineering degree and diploma institutions across the country. Based on the study, he has emphasized the need to focus on the stakeholders like faculty with measures for them to improve motivation levels. He also emphasizes on the need to focus on the students with greater industry based exposure and training.

On similar lines but in a different country, Pakistan, Masood (2007) based on his application and analysis of Total Quality Management in colleges of education in Pakistan covers colleges, faculty members and students emphasizes the need for engineering education to be practical skill oriented. Gulbarga et al (2012a) in their review exploring the impact of TQM on higher education also focus on similar points pertaining to client satisfaction, employee involvement and continuous improvement. In addition, they also lay emphasis on a dynamic curriculum for technical education that is continuously upgraded based on new developments in the field.

Efthimia (2006) also looks at TQM in technical education from a stakeholder perspective. Focusing on the process orientation she cautions against looking at TQM as a quick fix measure. Focusing on the implementation of the TQM approach and the challenges therein, she emphasizes the importance of leadership with a commitment to quality,

customer focus, employee empowerment and communication.

Sudha (2013) also focuses on the importance of stakeholder engagement to understand the level of schuss of a TQM approach to technical education. Based on a study involving faculty members from Technical, management and Pharmaceutical education, she emphasizes on the need to create synergistic relationship among the stakeholders.

Industry Interaction

Nair and Bannerjee (1982) based on their interaction with faculty of IITs and captains of the industries examine factors related to technical institutions (including IITs) not giving the desired and expected outcomes. They emphasize that engineering education curriculum, instructions and institutions are not relevant to the Indian industrial situation, in fact, they tend to become theoretical and esoteric. Both students and faculty look at options outside India and in other areas (publications in foreign journals, careers outside India, management courses) as options instead of relatively limited industry related possibilities in India. Focus on indigenous and high quality research, even in IITs, is low. To address these issues, the study recommends constant industry interactions to keep curriculum relevant and practical, increases role of academics in industrial establishments, make an engineering program flexible by having the first two years common and giving choices to specialize in years 3 and 4, offer a mix of technology and management courses. However, the study was largely restricted to IITs, a set of premier institutions and undertaken in an era when private education in engineering was almost non-existent. Also, it does not capture student perspective, is largely oriented around the perspective of educational institutions and the industry.

Bansal and Singh (2000) in their paper on the Role of Industry- Institute interaction in Curriculum Development had emphasised on the need to greater engagement with industries to enhance human

resource development that is sensitive to the growing and sometimes changing needs of the industries. Indicating some areas that should see greater collaboration, they include R &D support, knowledge transfer arrangements, shared facilities like computer labs, libraries, scholarship arrangements for students, engagement of industries in curriculum development and course design of the institutions and managing industry-institution collaborative projects. The authors specifically focuses on the engagement for curriculum development, given the fast changing nature of industrial development and the need for the educational institutions to keep pace with such changes. The authors suggest greater 'sandwich' programmes for student exposure to industrial settings, industrial visits, industry based teacher training programmes, exchange programmes involving teachers and industry personnel and summer placements of students to industries.

Murthy (2002) in his paper on Industry institute interaction describe different modes of industry-academia interaction. He presents an overarching view of the Industry-academia interaction based on his experience and examples from IIT Delhi. Looking at the modes for institute to industry, industry to institute and joint activity, he list down the support systems required for the same and the benefits of implementing these modes. The paper emphasizes that the subjects of prime importance to industry are in wide variance with what is taught in the classrooms. To address these, the following modes of interactions are recommended - Student (visits, interactions, internships, projects), Teachers (deputation, expert lectures), Industry (Depute personnel for higher education, assign consulting jobs, sponsor R&D projects, get industry experts to be resource persons and adjunct faculty), Joint actions (Consortiums in mission mode, Technology transfers, Prototyping, Field trials, International linkages)

Khanna (2012) based on his research using a qualitative approach to improvement in technical

education using Total Quality Management (TQM) has also emphasized on the need to focus on the students with greater industry based exposure and training. Masood (2007) based on his application and analysis of Total Quality Management in colleges of education in Pakistan emphasizes the need for engineering education to be practical skill oriented.

Gulbarga et al (2012a) also focus on similar points pertaining to continuous improvement laying emphasis on a dynamic curriculum for technical education that is continuously upgraded based on new developments in the field.

Gulbarga et al (2012b) in their study of the perception of staff and students on three categories of institutions with regards to the quality management practices also emphasize the need for greater and intense industry-institute interaction.

Barriers to TQM

Despite the many advantages, the TQM approach is not without its set of challenges with regard to implementation. Based on an Interpretive Structural Modeling (ISM) based on a series of interviews with experts and desk review of literature based approach to understand the barriers the ways these influence one another, Talib (2011) et al identify 12 barriers. Classifying these into two broad heads-a) those that are of high influence and strategic importance including such factors as inadequate commitments of the top management, lack of inter-departmental coordination and b) those pertaining to high levels of attrition at the managerial level, absence of a culture of regular improvement of quality and resistance on the part of the employee to any kind of change. Based on their engagement with these factors, the authors argue that an attention toward these barriers would considerably address the barriers to implementation.

Much earlier to this Grant et al (2002) based on their review of Higher education institutions in the United States had attempted to understand and analyze the implementation of quality in US higher

education through adherence to the management framework developed by Mergen in 2000, specifically assessing the three components of the model- quality of design, quality of conformance and quality of performance in the existing institutions. The study elicited that while Quality of design and quality of conformance could be found, quality of performance was one of the most difficult to assessed because of lack of data or lack of access to data. An assessment would require an ability to scrutinize the performance of alumni over a period and across organizations that might be difficult to access due to issues pertaining to consent as well as confidentiality issues of the organizations.

An important point raised by Brookers and Becket in their review paper that looked at the models developed and published in academic journals over a ten year period between 1996 and 2006 across 34 countries pertain to the approach taken by models for quality improvement. Questioning a privileging of a management approach over a Teaching and learning approach to Modelling, they argue that the focus of most models is on industry requirement. While they acknowledge the benefits in terms of improved results in managerial functions, they emphasize that most gains are in the realm of non academic functions end up relegating the academic to the second position,,privileging the managerial over the academic in Higher Education. They assert that institutions of higher learnings Universities need to rethink their approach placing academic activities at the core of their engagement.

TQM IN ENGINEERING EDUCATION: A CONCEPTUAL FRAMEWORK

For the purpose of the present study, TQM in Engineering Education is defined as an approach that is completely oriented around meeting and exceeding the satisfaction of all its stakeholders. As such, it is an approach that invokes the proactive participation and involvement of all its stakeholders

in achieving and sustaining high quality standards in Engineering Education. In engaging in the pursuit of quality enhancement, it remains process oriented and integrates diverse systems within the Engineering Educational institutions, interconnecting different functional specialties to ensure an institutional focus on implementing quality enhancement measures. It builds on a strategic approach with quality not just as a core component but as an area of continual improvement for the institution that can be sustained over time and supported by a robust evidence and fact -based decision making process.

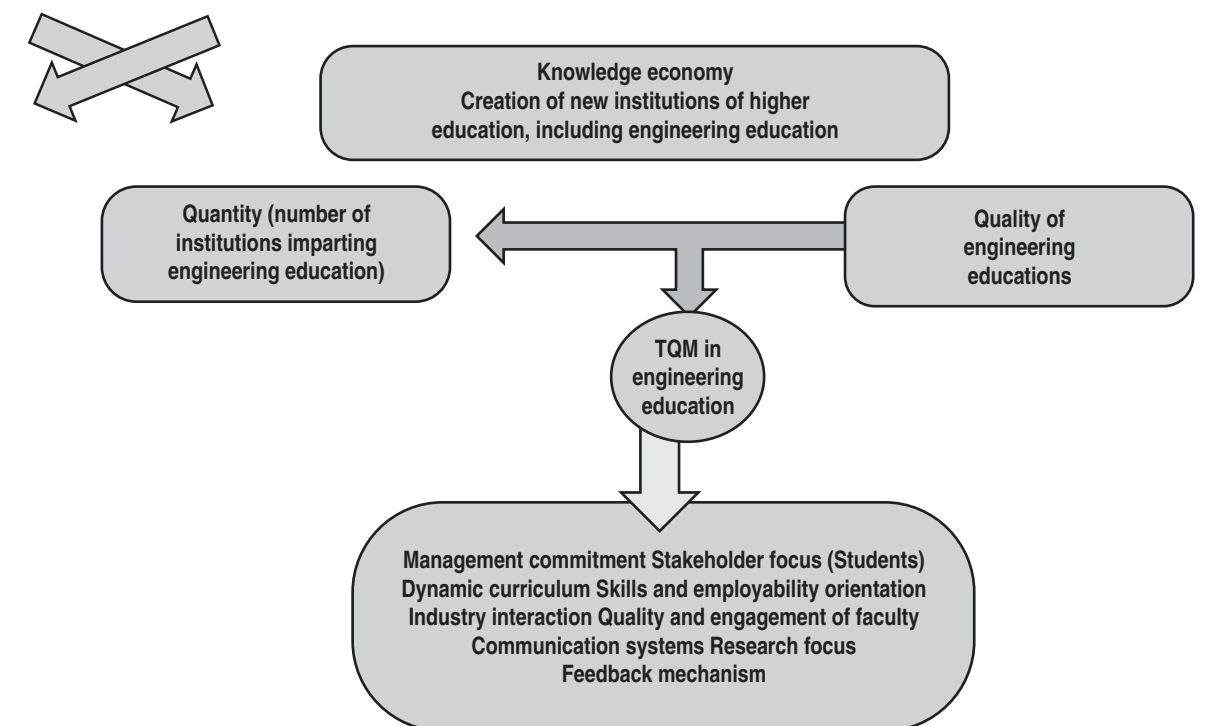
Conceptualizing TQM variables a 5-C Total Quality Model of academic excellence in engineering institutions of India has also been developed that includes: commitment of top management, course delivery, campus facilities, courtesy and customer feedback and improvement. Similar framework has also been developed for quality values in higher education which includes, course design, course

marketing, student recruitment, induction, course delivery, course content, assessment monitoring, miscellaneous and tangibles.

Understanding quality in education from TQM perspective, an educational institution may be viewed as an open system i.e. management system, technical system and social system. It includes within it the quality of input in the form of students, faculty, supporting staff and infrastructure, the quality of processes in the form of the learning and teaching activities and the quality of output including examination results, employment, earning and satisfaction.

This model takes into account some of the general principles of TQM like stakeholder satisfaction, communication systems and feedback mechanisms, it adapts them to the engineering education scenario and takes into account specific aspects related to engineering education like an up-to-date curriculum, a structured way of engaging with industry and research focus of faculty.

Figure 1 : Conceptual Model of TQM in Engineering Education



TQM IN ENGINEERING EDUCATION: A MANAGEMENT FRAMEWORK

Based on this review and the conceptual framework, the pathways for a management framework can also be spelt out. The management framework need to engage with different levels of Engineering Education, specifically Diploma, Undergraduate Graduate and Post Graduate level. All three levels have important implications for the industry. The Diploma programs equip the students with hands-on skills and capacities. The students, who complete this program, work at a supervisory level in Workshops, Power Stations, Operation and maintenance of sophisticated machines like Computerized Numerical Controlled (CNC) machines, Machining Centers and Flexible Manufacturing Systems, (FMSs) and also at middle level in Design Offices, etc.

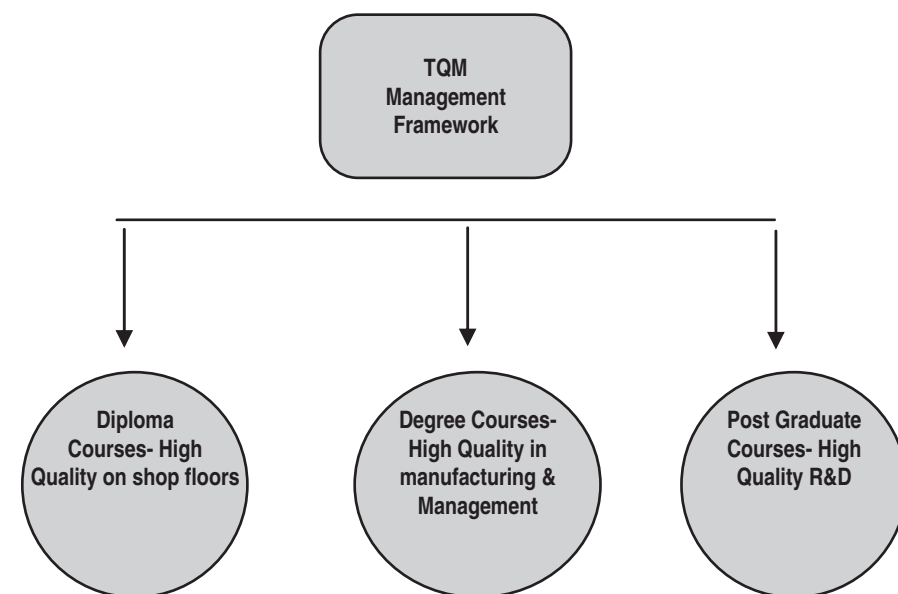
The Graduate programs provide a techno-managerial perspective. The students who complete this program work at Senior supervisory and/ or at Management levels in manufacturing organizations,

Design offices, software industry, Quality Control/ Quality Assurance, etc.. The Post Graduate programs provide the ground work for engagement in basic research students who complete this program engage themselves mainly in teaching activities and Research and Development activities.

Figure 2 depicts the ways in which the TQM model can be integrated in the Engineering Education. It illustrates the way in which the model can potentially contribute towards improved management across these three levels of Engineering education contributing eventually to high quality in terms of contribution to the industry.

Across these levels, in order to arrive at the institutions to be selected for detailed investigation towards ascertaining the quality of Engineering Education, the Universities/ Institutions can be classified as: Central Universities and National Institutes of Excellence under the Ministry of Human Resource Development; State Universities; Deemed Universities; Private Universities and; Institutions under the State Board of Technical Education.

Figure 2 : TQM results across levels and work stations



CONCLUSION

High quality Engineering Education corresponds to a set of requirements: not only is it an aspiration of millions of students, it is also the backbone of industrial development in the context of India that needs a driving force led by a skilled workforce. As the country positions itself as a knowledge economy, it has seen a tremendous spurt in the number of educational institutions, especially, engineering colleges. However, there are increasing concerns about the quality that makes it important to reflect on the nature and content of the growth and the direction that it has taken.

It is critically important also to invest heavily in enhancing the quality of Engineering Education that is presently being imparted. Given that TQM is acknowledged as a proven way of enhancing quality, it is important to look at its various components and indicate ways in which TQM principles can be used by the institutions to transform their systems and processes. In doing so, engineering education institutions have to not only progressively integrate the different components that the management framework facilitates but also look at dynamic ways in which it can evolve to continuously meet and indeed preempt the industry requirement.

Engagement with TQM as a conceptual as well as management framework for Engineering education, therefore, opens up a new visioning for Engineering education indicating concrete pathways to enhance the quality of such education which is of relevance for the entire country.

REFERENCES

- Achintya and Mishra (2000) Quality Assurance in Engineering Education The Indian Journal of Technical education, Vol 23, No 1 pp 79-81
- Anand, Geeta. 2011. India Graduates Millions, But Too Few Are Fit to Hire. Wall Street Journal, April 8. Available at: <http://www.prlog.org/10695114-educated-unemployment-need-for-skillbased-education-system.html>

Akhtar, Masood; Application and analysis of Total Quality Management in colleges of education in Pakistan ; University institute of education and research , University of Arid Agriculture,Rawalpindi, 2007

Bansal A S and Singh S (2000) Role of Insdutrty Institute Interaction in Curriculum Design, Bhat (2000), The Indian Journal of Technical education, Vol 23, No 1 pp 23-26

Bhat I K (2000) Quality Education in technical Institutions, The Indian Journal of Technical education, Vol 23, No 1 pp 1-7

Brookes M and Becket N Quality Management in Higher Education: A Review of International Issues and Practice

Babai KS, Dharmambal; "Total Quality in Engineering Education", The Journal of Indian Technical Education, Vol. 23, No. 3, July-Sep 2000

Bhattacharya SK, "Enhancing employability of pass-outs of technical institutions", The Indian journal technical education, Vol. 24, No. 3, July-Sep 2001

Chua Clare, "Perception of Quality in Higher Education", AUQA Occasional Publication, Proceedings of the Australian Universities Quality Forum 2004

Chandrakant S, Nair MNV, Bannerjee MK; "New perspectives for technical education - Industry interaction", Journal of Higher education, Vol. 7 No. 3 Spring 1982

Das Manik C., Sarkar Bijan, Ray Siddhartha; "Multi-criteria performance evaluation of Indian technical institutions by using MOORA method", The Indian Journal of Technical Education, Vol. 37, No. 3, July-Sep 2014

Dhend, MH and Biradar SK, "Elements of Quality engineering education", The Indian Journal of Technical Education, Vol. 23, No. 1, January-march 2000

FICCI Industry - Academia Convergence "Bridging the Skill Gap" available at http://www.ficci-hen.com/Knowledge_Paper_Industry_Academia_Convergence_Bridging_t%85.pdf accessed on 15th Jan 2013

Grant D (2002) et al Quality Management in US Higher Education Gulbarga Irfan, Chetty Soma V, Ganjigatti JP ; Explicit study on the implication of Total Quality Management on Higher Technical Studies ; International Journal of Mechanical Engineering applications research - IJMEAR, ISSN: 2249-6564; July 2012

Gulbarga Irfan, Chetty Soma V, Ganjigatti JP ; Prakash Sunil; Assessing technical institutions through the principles of Total Quality Management : the Empirical Study - 2; International Journal of Scientific and research publications , Volume 2, Issue 8, August 2012, ISSN 2250-3153

Ibrahim, Ola; Total Quality Management (TQM) and continuous improvement as addressed by researchers ; International Journal of Scientific and Research Publications, Vol. 3, Issue 10; October 2013; ISSN 2250-3153

Jain NK, Puri Manimala, Jindal Manish ; Some suggestions for

improvement in present technical education system in India; The Indian Journal of Technical education, Vol. 23, No. 2, April-June 2000, page 70-72

Khanna, Pradeep; Qualitative approach for improvement in technical education using Total Quality Management (TQM) concept; International journal of Scientific Engineering and Technology, Volume No. 1, Issue No. 2 pgs.: 175-178; ISSN : 2277-1581, 1st April 2012

Lagrosen Stefan, Seyyed-Hashemi Roxana and Leitner Markus, "Examination of the dimensions of quality in higher education", Quality Assurance in Education; 2004; 12, 2; Research Library, pg. 61

Loyalka P et al 2013. Getting the Quality Right: Engineering Education in the BRIC countries Stanford, CA: (unpublished)

Madan, AK, "Interpretive structural modelling (ISM) - A modern tool for Quality management in technical education", The Indian Journal of technical education, Vol. 37, No. 3, July-Sep 2014

Ministry of Human Resource Development (MHRD). 2011. Statistics of higher & technical education, 2009-10. New Delhi: Bureau of Planning, Monitoring & Statistics

Murthy SS, "Industry Institute Interaction - a vision document prepared for AICTE", The Indian journal for technical education, Vol. 25, No. 2, April-June 2002

Naik BM (2000) Internationalisation of Higher Education, The Indian Journal of Technical education, Vol 23, No 1 pp 82-84

Natarajan R, 2000, "Managing technical education in the XXI century - challenges and opportunities"; The Indian Journal of Technical education, Vol. 23, No. 3, July-September 2000

Natarajan R, 2000, "The Role of Accreditation in promoting Quality Assurance of Technical education", International Journal of Engineering Education, vol. 16 No. 2, pp 85-96

National Knowledge Commission (2009) Report to the Nation, Government of India available at www.knowledgecommission.gov.in/reports/report09.asp accessed on 10th Jan 2013

Planning Commission (2007) Planning Commission (XIth Five Year Plan 2007-2012), Government of India available at http://planningcommission.nic.in/plans/planrel/fiveyr/11th/11_v1/11v1_ch5.pdf accessed on 15th Feb 2013

Sakthivel, P.B. and Rajendran, G (2005), 'TQM Implementation and Students' Satisfaction of Academic Performance', The TQM Magazine, vol. 17, no. 6, pp. 574-589.

Sayed Begum, Rajendran Chandrasekharan, Lokachari Prakash Sai; An empirical study of total quality management in engineering educational institutions of India; Emerald, Benchmarking, an International journal Vol. 17 No. 5, 2010 pp 728-767

Staiou Efthimia, Total Quality Management in Engineering Education; 3rd WSEAS / IASME International conference on Engineering Education, Vouliagmeni, Greece, July 11-13, 2006 (pp

125-130)

Senthilkumar N and Arulraj A, "SQM-HEI - determination of service quality measurement of higher education in India", www.emeraldinsight.com/1746-5664.htm, Emerald Insights, JMP 6,1; Accepted 20th July 2010

Sudha T; Total Quality Management in higher educational institutions; International journal of social science & interdisciplinary research, 11551R, Vol 2(6), June 2013; ISSN 2277-3630

"Sohani Neena and Sohani Nagendra, "Developing Interpretive Structural Model for Quality Framework in Higher Education: Indian Context", Journal of Engineering,

Science & Management Education, J. Engg. Sc. Mgmt. Ed. Vol-5 Issue-II (495-501), Accepted 07th June 2012"

Talib F et al (2011) Analysis of interaction among the barriers to total quality management implementation using interpretive structural modeling approach Benchmarking: An International Journal Vol. 18 No. 4, 2011 pp. 563-587

Thandapani D et al (2010) Quality models in industrial and engineering educational scenarios: a view from literature in The TQM Journal, Vol. 24 No. 2, 2012 pp. 155-166

Tiwari D P (2000) Total Quality Management in Technical Institutions, The Indian Journal of Technical education, Vol 23, No 1 pp 67-69

Winn R C & Green R S (1998) Applying Total Quality Management to the Educational Process, International Journal of Engineering Education Vol. 14, No. 1, 24-29 available at <http://sinche.uom.gr/sites/default/files/ijee959.pdf> accessed on 6th May 2012

Umashankar V & Dutta Kirti: Balanced scorecard in managing higher education institutions- an Indian perspective. Emerald Insight IJEM 21,1 pp 54-67.

Verma, NK, "Industry-Institute Interaction: Introspection and Involvement", The Indian journal of technical education, Vol. 25, No. 2, April-June 2002

Willis, T Hillman and Taylor, Albert J; "Total quality management and higher education: The employers' perspective", Total Quality Management 10(7):997-1007 ·September 1999

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At present, Shri Sapra is a visiting Faculty at the PTU Nalanda School of TQM & Entrepreneurship, Mohali and a Guest Faculty at his Alma Mater, the PEC University of Technology, Chandigarh. By virtue of his passion and zeal to learn continuously, he is also successfully registered for Ph. D. at the Chitkara University with a carefully chosen subject as 'Designing a model for Total Quality Management in Engineering Education'. Shri Sapra is a Life Member of the Indian Society for Technical Education (ISTE) and Indian Institution of Industrial Engineering (IIIE), and also a Fellow of the Institution of Engineers (India).