Quality Management
In
Technical Education

A thesis submitted to the Faculty of Technology, University of Delhi in the fulfillment of the requirements for the award of Degree of

DOCTOR OF PHILOSOPHY

In

Production Engineering

Submitted by

ASHOK KUMAR MADAN

Under the Supervision of

Prof. (DR) R.S. Mishra

Professor, Department of Mechanical Engineering,

Faculty of Technology, University of Delhi,

Delhi-110007

Department of Production Engineering

Faculty of Technology, University of Delhi, Delhi-110007 (INDIA)

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Certificate

This is to certify that the thesis entitled "Quality Management in Technical Education" submitted by Mr. Ashok Kumar Madan to the Department of Production Engineering, Faculty of Technology, University of Delhi, for the award of degree of Doctor of Philosophy, is bonafide record of research work carried out by him. He has worked under my supervision and guidance and has fulfilled the requirements for the submission of this thesis, which has attained the requisite standard for a Ph.D degree of the university of Delhi. The work carried out in this thesis has not been submitted to any other university or institution for the award of any other degree or diploma.

Prof. R.S. Mishra
Supervisor
Department of Mechanical Engineering,
Faculty of Technology
University of Delhi,
Delhi-110007 (INDIA)

Prof. Raj Senani
Dean Faculty of Technology & Head
Department of Production Engineering,
Faculty of Technology
University of Delhi,
Delhi-110007 (INDIA)

"Dedicated

to

My Parents"

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Ashok Kumar Madan

Department of Production Engineering

Delhi College of Engineering, Delhi-110042

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ABSTRACT

TITLE: Quality Management in Technical Education

(I) Introduction

Education is an important aspect for the development of economy and to be self sustained. It predicts the growth and living standard. Quality education is an absolute necessity at every level of society. The main stakeholders of any **Technical Education System (TES)** are faculty, students, management and the infrastructure, which are responsible for efficient functioning of a TES. There is an utmost need to provide good quality technical education. In order to achieve it there is a need to develop certain procedures which would help in assessing the standard and quality of technical education so that its quality can be improved and monitored from time to time. In this work research on various aspects of technical education has been done by using different techniques. The basis of the research is provided by the literature review done.

In education, quality means good academic culture, excellent academic results, progressive and adaptive management, clean administration and prominent profile of outgoing students. It involves the expectations and perceptions of students, faculty, supporting staff, administrators, parents of the students, government, industry (recruiters) and society etc. They interact with the system in different ways and their objectives may be different. So the implementation of a quality improvement program necessitates the identification of various factors in an educational set-up and determination of their criticality. Sometimes the stakeholders are classified into three groups: input, transformation and output. Students and parents are included in input stakeholders, the faculty is the transformation stakeholders and the corporations and society are the output stakeholders. The main objective of a TES is the development of methodologies for improving the quality of education and establishment of a new system of its own.

(II) Motivation for research

Some of the factors which motivated me to undertake the subject research work are as under:

- Due to globalization we need more and more technical manpower of high quality in the industries, research centers and institutions.
- The number of the technical institutions is increasing exponentially under the govt. efforts of liberalization and reform of higher technical education to make India the largest English speaking technical manpower of the world.
- Industry is becoming more competitive locally as well as globally and for that we need higher number of technical manpower at all levels. For this improvement in the quality of TE is must and is a need of hour.
- The rapid growth in the knowledge and technology makes the technical curriculum obsolete quickly. Therefore, technical institutions, industries and

research centers need to maintain close contacts, inter-academia partnership and higher quality standards in technical education.

- Under the present scenario and for the reasons already stated, a lot of sub-standard technical institutions have already come up and many are in the pipeline to get established.
- These institutes are merely producing technical graduates who do not meet the expectations of the industries.
- Further there is greater amount of technical students and professionals across national borders making it imperative and concerned agencies not to be restricted to national considerations only. Therefore, high quality standards have to cater for global processes of internationalism in TE.

(III) Literature Review & concluding remarks

The literature is replete with various works bordering on university admission, student performance, and related problem. In 1954, the University of New Zealand Council for Educational Research investigated the relationship between academic standards of students on entrance and their first year university work. The study found that the median correlation found among the many sets of variables representing general school performance and general university performance was indicated by a *tau* coefficient of 0.36 for the first year students undertaking their studies on a full time basis. In 1975, C.G.M. Bakare summarized the factors and variables affecting student's performance into the intellective and non-intellective factors, emphasizing that the intellectual abilities were the best measure (C.G.M. Bakare 1975). He categorized causes of poor academic performance into four major classes: (i) Causes resident in society, (ii) Causes resident in school, (iii) Causes resident in the family, (iv) Causes resident in the student. Studies such as Lage and Tregelia, 1996 and Dynan, 1977 looked at a more general aspects of success while Anderson, (Anderson, G., Benjamin, D. & Fuss, M.,1994) studied the effect of factors such as gender, student age, and students' high school scores in mathematics, English, and economics, on the level of university attainment. According to their study, students who received better scores in high school also performed better in university. Another aspect discovered was that men had better grades than women and choose to drop from school less often. Johnes (Jill Johnes, 2006) analysed the teaching efficiency of the teachers using Data envelopment analysis (DEA) technique. The results suggested that efficiencies derived from DEAs performed at an aggregate level include both institution and individual components, and are therefore misleading. Temponi (Cecilia Temponi, 2005) analyze the main elements of Continuous Improvement (CI) in higher education and the concerns of academia's stakeholders in the implementation of such an approach. Thakkar (Jitesh Thkkar, Anil Shastree, 2006) used a Quality Function Deployment (QFD) which prioritizes technical requirements and correlates them with various customer students' requirements for the present Indian context. As an extension to the basic model of QFD House of Quality (HOQ), the scope for futuristic improvements is explored through a four-phased QFD process. Challenges involved in the implementation of TQM are investigated using an approach of force field analysis. They recognized the need for continuous improvement, cultural change and effective use of financial resources to improve the value addition at each level. They developed an understanding of the issues to be addressed at each phase of TQM implementation. Mahapatra S. S. and Khan M. S (2007) gave a measuring instrument known as EduQUAL for evaluation of quality in Technical Education System (TES). They carried out a Factor analysis on responses obtained through cross-sectional questionnaire survey on various items to validate dimensionality of the instrument and it is found that 28 items loaded above 0.5. Neural network models have been proposed to assess the degree of satisfaction of various stakeholders in TES. Mahapatra S. S. and Khan M. S (2007) designed a measuring instrument known as EduQUAL and an integrative approach using neural networks for evaluating service quality is proposed. The dimensionality of EduQUAL is validated by factor analysis followed by vari-max rotation. Four neural network models based on back-propagation algorithm are employed to predict quality in education for different stakeholders. The study demonstrated that the P-E gap model is found to be the best model for all the stakeholders. Sensitivity analysis of the best model for each stakeholder was carried out to appraise the robustness of the model. Finally, areas of improvement were suggested to the administrators of the institutions. Cristea L. and Gogoncea D.,(2006) applied fuzzy approach in quality management of higher education. They concluded that that the adoption of the fuzzy formalism is a possible solution to the standardization in the domain of quality, in which to the usual terms are still given various meanings by the managers of various firms, on markets that visibly oscillate between globalization and regionalization.

The literature review shows the importance of quality management in technical education. It also shows the need and importance of quality management. Hence we can conclude that there is an immense scope of research in the field as very nominal amount of work has been done in this area of research.

The literature review concludes that there is an utmost need of quality management in technical education. It shows the extensive work carried in the field of research. It also shows the need and importance of quality management in technical education. The literature review also states the various techniques used for quality management in technical education.

(IV) Summary of review and gaps identified

The extensive literature review gives us the brief knowledge about the work done to control the quality of technical education over the years. It also shows the developments and the need of the research. We can see the importance of the education sector and various models proposed to monitor the quality of technical education. Various scientists have done research in the field of technical education. Various techniques have been employed for this purpose but no technique is found to be very accurate. Techniques like ANN, Fuzzy logic, SPC, Fuzzy AHP and ISM have not much been used in quality management in technical education. Hence, there is a need to apply these techniques and find out how these can be used for improving the quality in technical education and to evaluate their potential for quality management in technical education.

(V) Objectives of the Research

The present study attempts to adopt holistic approach for analyzing various soft computing and other techniques to improve the quality in Technical Education. On the basis of literature review and gaps identified this research is aimed to achieve the following objectives.

(i). To assess the potential/ accuracy of ANN to improve the quality in technical education with regards to academic results.

(ii). To develop Fuzzy logic Models for predicting placement of the students and assessing the factors affecting the quality in Technical Education.

(iii). Systematic integrated approach for modeling various attributes affecting the quality in Technical Education System (TES).

(iv) To determine the rank of the attributes capable of affecting quality of a TES using Fuzzy AHP and to test the adequacy of Fuzzy AHP for modeling the Attributes of quality in education.

(v). To develop a hierarchy of various factors to improve the quality in Technical Education System (TES) using interpretive structural modeling (ISM).

(vi). Ranking and comparative study of Engineering colleges using SPC, statistical method/ Survey analysis etc to improve the quality in Technical Education.

(VI) Research Methodology

At present very little amount of research work seems to have taken place in this field. Some of the applications including soft computing techniques used in the present research work are:

- Artificial Neural network
- Fuzzy logic
- Analytical Hierarchy Process (AHP)
- Statistical Process Control (SPC)
- Interpretive Structural Modeling (ISM)

The above techniques are used very effectively and have also proven to give good results and hence helped to control the quality of technical education. In this work we have used various methods for improving and analyzing the quality of technical education. The research resulted in successful implementation of all the above mentioned techniques in the field of technical education. This gives us a new breakthrough in this field of research and also shows the efficient results that were obtained using the above mentioned techniques. The use of soft computing and other techniques namely, ANN, Fuzzy Logic and MATLAB, SPC, Fuzzy AHP and ISM have greatly helped in assessing and controlling the quality of technical education.

Results from each technique give us unique results to improve the quality in technical education. The research depicts the need for good quality education and also shows its importance. Most of the methodologies used in the research are the soft computing techniques and have not much been applied earlier in this field. Study has shown the potential of ANN for enhancing the university admission system. An accuracy of over 73% was achieved by the application of Artificial Neural Network technique. This shows the efficiency of the ANN methodology as a prediction tool for selection criterion for candidates seeking admission into a university.

The Fuzzy Logic technique has also been applied for prediction of the ranking of various factors in technical education system. A non traditional approach has been proposed to infer statistical and Fuzzy rules from quantitative database. Fuzzy Logic tool of MATLAB software was used for the analysis work. This application has been used to assess the placement of the final year students.

SPC is applied to analyze the result of second semester examination of an institute in NCR region, of all the streams held in MAY/JUNE-2009. The technique proves to be effective and the SPC control chart shows the problems occurring in the streams.

Fuzzy AHP is an effective Multi Criterion Decision Making (MCDM) technique and can be used effectively for assessing quality in technical education. Since we are aware of the fact that in today's world, decisions are made in increasingly complex environments. Fuzzy decision making theory is used in the present investigations. This research concludes that Fuzzy AHP is an effective MCDM technique and can be applied in the education sector for assessing quality in technical education.

There are four main attributes: faculty quality, students' quality, management input, infrastructure. Among the four main attributes, Faculty Quality is the most important, followed by Management Inputs, then Students Quality and in the end Infrastructure. Some of the very important Sub Attributes are (global weight >0.04) as follows: Good Communication Skills (GCS), Curriculum Design (CD), Qualification of Faculty (Qua), Timely Assessment of Faculty & Students (TA F& S), Teaching & Industrial Experience (T&I Ex), Training & Placement (T&P), Background & Merit of Entering Students (B&M ES), Well Equipped Labs and Classrooms (WE L&C), Attitude Towards Learning (ATL).

The objective of the Interpretive Structural Modeling (ISM) is to develop a hierarchy of enablers that would help in management of quality in a technical education system. Quality of Technical education can improve in effective manner if all the variables are improved in the given hierarchy. The driver dependence diagram helps in classifying various enablers of effective Technical education system. Most of the techniques used in this research work indicate their effectiveness in achieving the desired goal.

A case study has been done on comparison of different Engineering colleges under university system. The comparison has been done on the basis of various parameters like ISO certification of college, department and labs, Accreditation of college, department, laboratory, UG courses and PG courses, research activities in college and department. UG and PG courses offered both in the department, passing percentage of the students both at UG and PG level in each branch for the college and department, number of PhD holders(faculty) in the college and department, student placement, research scheme offered books published, research paper publication, etc.

With regards to the ranking of the engineering institutes in a university system certain parameters of acceptance have been considered.

Extensive literature review on the research work consists of review of various research papers ranging from 1970's to 2008 to find out the gaps in the research done in the field of the quality in technical education. It has been observed that soft computing techniques viz ANN, Fuzzy logic, Fuzzy AHP are not used much in the field of quality management in technical education. Statistical process control, ISM etc have been used in the industries for various studies but have not been used much to improve the quality in technical education. Usage of MATLAB along with FUZZY logic can be highly beneficial.

(VII) Case Studies from the research

Eight case studies have been made as under:

1. Case study No. 1-Application of ANN for Quality Management in Technical Education. *Part of this case study is published in the Indian journal of technical education, Vol. 32,No.4,PP 68-77, 2009 (ISSN 0971-3034)*
2. Case study No. 2-Prediction of quality of technical education using Fuzzy Logic. *Part of this case study is published in Journal of Multidisciplinary Engineering Technologies Vol.4 No. 1, July-December 2009pp-19-28 (ISSN 0974-1771).*
3. Case study No. 3-Predicting Student's Campus Placement using Fuzzy Logic (MATLAB).
4. Case study No. 4-Application of Statistical Process Control (SPC) for Quality Management in Technical Education. *Part of this case study is published in Global Journal of Finance and Management Vol. 3, No. 1, 2011 PP -25-33 (ISSN 0975-6477)*
5. Case Study No. 5-Application of Fuzzy-Analytical Hierarchy Process Approach (AHP) for assessing Quality in Technical Education. *Part of this case study is published in Journal of Multi-Disciplinary Engineering Technologies Vol-4 No-1, July-Dec 2009 PP 34-45(ISSN 0974-1771)*
6. Case Study No. 6-Application of Fuzzy AHP for Multi-Attribute Comparison of Technical Institutions/Colleges: An expert Approach. *Part of this case study is published in the International Journal of Applied Engineering Research, Vol. 5, No. 21-22, 2010 PP -3455-3467 (ISSN 0973-4562).*
7. Case Study No. 7-Analysis of the variables for Quality Management in Technical Education using Interpretive Structural Modeling (ISM). *Part of this*

case study is published in the International Journal of Applied Engineering Research, Vol. 6, No. 2, 2011 PP -211-219 (ISSN 0973-4562).

8. Case Study No. 8 Ranking of Engineering Colleges based on Statistical Method and Survey Analysis to Assess the Quality in Technical Education. *Part of this case study is published in the International Journal of Applied Engineering Research, Vol. 6, No. 2, 2011 PP -201-209 (ISSN 0973-4562)*

(VIII) Chapter plan

The thesis consists of six chapters. The plan is as follows:

Chapter 1 is of Introduction, which gives introduction about the quality in technical education. This chapter shows the need of quality in technical education, its importance and the present quality of technical education. Important attributes have been listed in brief. A relation between industry and education has been displayed in brief.

Chapter 2 is of Literature Review which gives an extensive literature review on the research work. The literature review consists of review of various papers ranging from 1970's to 2010. The literature was studied in detail to find out the gaps in the research done in this field.

Chapter 3 is of research and methodology which gives a description of all the techniques used for research work. Various methodologies used are ANN, Fuzzy Logic, SPC, Fuzzy AHP and ISM.

Chapter 4 is of Application of various techniques of Quality Management in Technical Education. Seven case studies have been described in this chapter. Most of these case studies have been published in the journals.

Chapter 5 is of Ranking of Engineering Colleges based on Statistical Method and Survey Analysis to assess the Quality in Technical Education.

Chapter 6 is of summary & conclusions, references, appendices, list of publications, etc.

IX. Results & Conclusions

- The artificial neural network to enhance the effectiveness of a university admission system for improving the quality in Technical Education is quite useful. The model was developed based on some selected input variables from the pre admission data of five different sets of university graduates. It achieved an accuracy of over 73%, which shows the potential efficacy of Artificial Neural Network as a prediction tool and a selection criterion for candidates seeking admission into a university. One limitation of this model stems from the fact that not all the relevant performance influencing factors are obtainable from the pre-admission record forms filled by the students. A model incorporating the use of results from a carefully designed oral interview administered to the students may likely be an improvement over the present model. Also the extension of this model to non-engineering departments is recommended. The current admissions system should be reviewed in order to improve the standard of candidates being admitted into the institution. A more adequate ANN may be very useful for such an exercise.

- A model using Fuzzy logic and Matlab on the basis of expert opinions has been developed. This model can be used to evaluate the improvement in the quality in technical education by varying various factors. This model has been highly successful. Similar has been developed and used to predict the placement on the basis of data of the placements of the previous years. Actual results of the placements are very much in line with the predicted data on the basis of this model. Hence this model can be used successfully for the purpose of the placement in Technical Institution.
- A non traditional approach has been proposed to infer statistical and Fuzzy rules from quantitative database. Each factor was assigned with several fuzzy sets. Using fuzzy set concepts, fuzzy rules were inferred then Mat Lab Fuzzy logic tool box is used for generating rules. Here we use only few parameters for analysis but this approach suggest that for large data base decision can be taken more effectively than traditional methodology with less mental fatigue. This method is just one of the many methods used to generate rules in an adaptive system. Though a simple are discussed here to know the system, it is important to realize how powerful this system is. Research is currently being made to use adaptive systems to model events in politics, history, medicine and even military planning. Consider the way the human beings learn. We all learn through experience and through experience we become smarter. Whether, it is the smell of lime, or the picture of our mother, we remember things as it is given to us. With memory, we improve on our actions or thoughts and by definition become smarter. Fuzzy logic can be applied the same way. Instead, of depending on humans to put specific fuzzy rules to deal with every situation, the machine should be able to produce its own rules through experience. This can be done with the Data in Rules. FL does not require precise inputs, but It uses an imprecise but very descriptive language to deal with input data more like a human operator. Fuzzy Logic provides a completely different, unorthodox way to approach a control problem. This method focuses on what the system should do rather than trying to understand how it works. One can concentrate on solving the problem rather than trying to model the system mathematically, if that is even possible. This almost invariably leads to quicker, cheaper solutions. Once understood, this technology is not difficult to apply and the results are usually quite surprising and pleasing.
- SPC is applied to analyze the result of second semester examination of all the streams held in MAY/JUNE-2009. The technique proves to be effective and the SPC control chart shows the problems occurring in the streams. The study shows that there is a need to investigate the PE stream as in both the control charts their values are crossing the control limits (LCL, UCL). There is a need to identify the following causes of the problems so that the quality can be improved.
    - Qualifications and merits of the student entry.
    - Faculty expertise
    - Adequacy of subject teacher

- Effective classroom management
- Faculty's rapport with student and
- Student's understanding level

➢ A good quality TES is a major requirement for colleges and universities. Hence management should make sure that the TES should be constructed in the proper manner considering the important factors or attributes of technical education. Fuzzy AHP is an effective MCDM technique and can be used effectively for assessing quality in technical education. Since we are aware of the fact that in today's world, decisions are made in increasingly complex environments. Fuzzy decision making theory can be used for this purpose. This research concludes that Fuzzy AHP in an effective MCDM technique and can be applied to the education sector for assessing quality in technical education.

Among four Main Attributes, Faculty Quality is the most important, followed by Management Inputs, then Students Quality and in the end Infrastructure is the least important attribute among the four.

In terms of the Sub Attributes the very important Sub Attributes are (global weight >0.04) as follows: Good Communication Skills (GCS), Curriculum Design (CD), Qualification of Faculty (Qua), Timely Assessment of Faculty & Students (TA F& S), Teaching & Industrial Experience (T&I Ex), Training & Placement (T&P), Background & Merit of Entering Students (B&M ES), Well Equipped Labs and Classrooms (WE L&C), Attitude Towards Learning (ATL).

This methodology has also been used successfully to evaluate the priority weights. Ranking of Engineering is made on the basis of model "Priority Weight" and Statistical Method/Survey Analysis (using Fuzzy logic as soft computing technique).

- Interpretive structural modeling is a possible solution for modeling of various parameters to rank them as per criticality for improvement in quality of technical education. Interpretive structural modeling is useful for analyzing the effect of various factors on quality of Technical education that result in effective & precise decision making. This technique helps to develop a hierarchy model that includes the variable in order of their role for improving the quality of technical education. Driving power and dependence bring the related variable at common level. This technique works on the interrelationships among the variables.
- The ranking of the colleges is important in the university system since it indicates the scope of improvement of the institute. Analysis has been done to evaluate the area in which the improvement of the quality is required. Institutes having better quality of the faculty, placement of the students, Infrastructure and management inputs are found as higher in the ranking. Adopted methodology is quite useful in university system as well. However, certain modifications viz. interaction and collaboration of the programs with foreign universities is required. Ranking of colleges has been prepared on the basis of eight parameters. The Grade D college needs to improve their quality in technical education. There should be proper research activities and institution should enhance this activity on a wide spectrum.

Comparative results are arranged in a tabular form for a better understanding of quality status of these institutes.

The work done shows the need of quality control in technical education and also illustrates its importance. Various techniques have been applied for assessing quality in technical education. All the techniques used show its effectiveness in achieving the desired goal.

(X) Scope for future work

- Though an accuracy of 73% is achieved using ANN, further improvement may be possible with more relevant performance influencing factors obtainable from per admission record forms filled by the students.
- Factors with regards to performance of the students 1st semester to 8th semester can also be considered to prepare model for the placement using Fuzzy Matlab.
- Although experts from all parts of India participated in survey but majority of the expert were from north part of India. Therefore, this study can be extended on cluster or reason basis.
- In developing ISM model 14 factors have been considered. These factors are internal in nature as far as the quality of Technical Education is concerned. External factors viz. approval from AICTE, accreditation of various programs, Government policies can be considered for further studies and research.

The research work has been limited to improve the quality in Technical Education. Research can be extended to non-engineering departments/colleges.

XI. References

1. P. Venkataram & Anandi Giridhar, 2007, "Quality Assurance & Assessment in Technical Education System: A Web Based Approach "International Conference on Engineering Education – ICEE 2007.
2. Bakare, C.G.M., 1975, "Some Psychological Correlates of Academic Success & Failure", African Journal of Educational Research.
3. Dyman K. & Rouse C., 1997, "The under Utilization of Women in Economic: A study".
4. Lage, M. & Tregelia, M., 1996, "The Impact of Integrating Scholarship on women into Introductory Economics: Evidence from One Institution", Journal of Economic Education, Vol 27, Pages 26 – 36.

5. Anderson, G., Benjamin, D. & Fuss, M., 1994, "The Determinant of Success in University",Journal of Economic Education,Vol 25,No 2,Pages 99-119.
6. Jill Johnes, 2006, " Measuring teaching efficiency in higher education : An application of data envelopment analysis to economics graduates from UK Universities 1993", European Journal of Operational Research, Vol 174, Pages 443 – 456.
7. Cecilia Temponi, 2005, " Continuous improvement framework : Implications for academia", Emerald Group, Quality Assurance in Education, Vol 13, No 1, Pages 105 – 108.
8. Jitesh Thkkar, Anil Shastree, 2006, "Total Quality management (TQM) in self financed technical institutions", Emerald Group Quality Assurance in Education, Vol 14, No 1, Pages 205 – 219.
9. SS Mahapatra & MS Khan, 2007, " A neural network approach for assessing quality in technical education : an empirical study", International Journal of Productivity and Quality Management, Vol 2,No 3,Pages 287-306.
10. CRISTEA L. 2006 "Quality management or management of quality in higher education" XI International Conference man in the knowledge based organization, Sibiu, Romania, Pages 72-75.
11. Roediger Voss, Thorsten Gruber, 2006 "The desired teaching qualities of lecturers in higher education: a means end analysis", Quality Assurance in Education, Vol 14,No 3, Pages 217 – 242.
12. S.S Mahapatra and M.S Khan 2007 "A framework for analyzing quality in educational settings European Journal of Engineering Education, Vol 32 No 2, pages 205 – 217.
13. Yau Tsai, Sue Beverton, 2007 "Top-down management: an effective tool in higher education?" International Journal of Educational Management, Vol 21, No 1, Pages 6–16.
14. Hartini Ahmad, Arthur Francis, Mohamed Zairi 2007 **"**Critical success factors; Business process reengineering; Higher education", Emerald group, Business process management Journal, Vol 13,No 3, Pages 451-469.
15. Gitachari Srikanthan, John F. Dalrymple, (2007) "A conceptual overview of a holistic model for quality in higher education", International Journal of Educational Management, Vol. 21, No 3, Pages 173-193.
16. Yousif Bahzad and Zahir Irani (2008), "Developing a Quality Assurance Model for Small Military Institutions", 10 European and Mediterranean Conference on Information Systems (EMCIS2008), Al Bustan Rotana Hotel, Dubai.
17. Gheorghe, C.M.; Constantinescu, D.; Covrig, M.; Fac. of Electr. Eng., Politeh. Univ. of Bucharest, Bucharest (2008) , "The determination of factors underlying decision making process on quality improvement in technical education," IEEE.
18. Ziren Wang, Ronghua Liang (2008), "Discuss on Applying SPC to Quality Management in University Education,",The 9th International Conference for Young Computer Scientists, Pages 2372-2375.

19. Prof. dr. eng Lidia Cristea;Lecturer dr. eng. Dan Gogoncea (2008)” Fuzzy Approach in Quality Management of Higher Education” , Systems Engineering, 2008. ICSENG '08. 19th International Conference, Pages-553-554.
20. C. M. Bhatia**,** Smita Bhatia (2008)” An Integrated Approach for Restructuring Higher Technical Education”, Global Journal of Flexible Systems Management, Vol 9, No1, pages 2-3.
21. Hafiz Muhammad Inamullah,M.Naseeruddinand Ishtaq Hussain (2009),”The development of technical education in pakistan”, International Business & Economics Research Journal – January 2009, Vol 8, No-1, Pages-87-90.
22. Bakare C.C (1975),” Some Psychological Correlates of Academic Success and Failure”,African Journal of Educational Research, Vol 2, No-20, Pages 11-22.
23. Lage,M and Tregelia,M (1996),” The impact of integrating scholarship on women into introductory economics:evidence from one institution”,Journal of economic education, Volume 27, No 1, Pages 26-36.
24. Dynan,K and Rouse,C(1997),” the underutilization of women in economics”, journal of economic education, Vol 28, No-4, Pages 350-368.
25. Anderson,G;Benjamin,D;Fuss,M(1994) ,” The determinant of success in university”,Journal of economic Education, Vol. 25.
26. Mamun, M.Z (2000) ,” Total quality management of the non-government universities in Bangladesh”, Management of Innovation and Technology, 2000. ICMIT 2000. Proceedings of the 2000 IEEE International Conference Vol 1, No 1, Pages 305-309.
27. Zadeh,L (1965) ,” Fuzzy sets”, Information and Control, Vol 8, No 1Pages 338-353.
28. P.J.M. van Laarhoven* and W. Pedrycz (1983),”A fuzzy extension of Saaty's priority theory”, Fuzzy Sets and Systems, Vol 11, No1-3, Pages 199-227.
29. Kahraman,C; Ulukan,Z; Tolga,E (1998),” A fuzzy weightes evaluation ,ethod using objective and subjective measures”, proceedings of the international ICSC symposium on engineeringof intelligent systems(EIS’98), Vol 1, Pages 57-63.
30. Deng,H (1999) ,”Multicriteria analysis with fuzzy pairwise comparison”, International Journal of Approximate Reasoning, Vol 21, No 3, Pages 215-231.
31. Mindy Lee, Hoang Pham* and Xuemei Zhang (1999) ,” A methodology for priority setting with application to software development process”, European Journal of Operational Research, Vol 118, No 2, Pages 375-389
32. C.H Cheng (1999) ,” Evaluating attack helicopters by AHP based on linguistic variable weight “,European Journal of Operational Research, Vol 116, No 2, Pages423-435.
33. Ke-Jun Zhu, Yu Jing and Da-Yong Chang (1999) ,”A discussion on Extent Analysis Method and applications of fuzzy AHP”, European Journal of Operational Research, Vol 116, No 2, Pages 450-456
34. Cengiz Kahraman, Ufuk Cebeci and Da Ruan ,”Multi-attribute comparison of catering service companies using fuzzy AHP: The case of Turkey”, International Journal of Production Economics, Vol 7, No 2 Pages 71-184.

35. Da-Yong Chang (1996) ," Applications of the extent analysis method on fuzzy AHP", Applications of the extent analysis method on fuzzy AHP, Vol 95 No3, Pages 649-655.
36. Ching-Hsue Cheng (1997) ," Evaluating naval tactical missile systems by fuzzy AHP based on the grade value of membership function", European Journal of Operational Research**,** Vol 96,No-2, Pages-343-350.
37. M. Weck, F. Klocke, H. Schell and E. Rüenauver (1997) ," Evaluating alternative production cycles using the extended fuzzy AHP method", Vol 100 No-2, Pages-351-366.
38. Da-Yong Chang (1992) ," Extent analysis and synthetic decision,optimization techniques and applications", World scientific research,Singapore, Vol 1,pages 352.

XII. Details of Research Papers Published in International/National Journals

1. A.K. Madan and R.S. Mishra, 2009 "Forecasting the academic results of students using ANN: A case study of an engineering college" IJTE vol.32, no.4, PP-68-77 (ISSN 0971-3034).
2. A.K. Madan and R.S. Mishra, 2010 "Application of fuzzy AHP for Comparison of Engineering institutions: An expert approach". "International Journal of Applied Engineering research" vol-5 No. 21-22, PP-3455-3467 (ISSN No. 0973-4562).
3. A.K. Madan and R.S. Mishra, 2011, "Application of Statistical Process Control for Quality management in technical education". "Global Journal of Finance and management" Vol.3 No.-1, PP-25-33 (ISSN No.0975-6477).
4. A.K.Madan and R.S. Mishra, 2011 Ranking of engineering colleges based on Statistical method and survey analysis to assess the quality in technical education. "International Journal of Applied Engineering research" PP-201-209, Vol.-6 No.-2 (ISSN No. 0973-4562).
5. A.K. Madan and R.S. Mishra, 2011 Analysis of variables for quality management in technical education using interpretive structural modeling "International Journal of Applied Engineering research" PP-211-219, Vol.-6 No.-2 (ISSN No. 0973-4562).
6. A.K. Madan et al. 2009 Prediction of quality in technical education using Fuzzy Logic. "Journal of Multidisciplinary Engg. Technologies" vol-4, No.-1 July-Dec PP19-28 (ISSN 0974-1771).
7. A.K. Madan et al 2009, A Fuzzy AHP approach for Assessing Quality in technical education. "Journal of Multidisciplinary Engg. Technologies", vol-4, No.-1 July-Dec, PP 34-45 (ISSN 0974-1771).
8. A.K.Madan and R.S.Mishra, 2011 Comparative study of Technical Institutions using Fuzzy Logic: "A Soft Computing Tool" to assess the quality in engineering education ." Global Journal of Finance and Economic management" Vol.1, No. 2, PP 95-108 (ISSN No.0975-6477).

"BIOGRAPHICAL PROFILE OF THE RESEARCHER"

1958 - Born in New Delhi, India, 15th April.

Academics

2011- Currently a candidate for the degree of Doctor of Philosophy in Production Engineering from University of Delhi, Delhi, India.

1981- Post Graduated from The City University, London, U.K

1979- Graduated from Delhi College of Engineering, University of Delhi, Delhi, India.

Experience (Appr-30 years)

- Joined Delhi College of Engineering, Delhi as a faculty in April 1991.
- Currently working as Associate Professor in the Department of Production and Industrial Engineering, DTU (formerly Delhi College of Engineering) Delhi.
- M/S Empire Industries LTD: January 1987- April 1991 (Asstt. Manager) Projects/ Products related to CAM/Automation etc.
- M/S K.G. Khosla Compressors L.T.D. Fbd.- June 1983 – January 1987 (Sr. Engr.) Projects/ Products related to CAM/Automation, Production Engineering., R&D etc.
- M/S GEC, LTD, UK 1981 -1983, Production Engg. Dealt with the projects/ products related to CNC Technology, APT, ASRS etc.

Publications

More than 25 publications in National / International Journals and conferences.

Affiliation/Membership

- Life Member, Indian Society of Technical Education, Delhi, India
- Have been Associate Member – Institution of Mechanical Engrs.

Address:

Ashok Kumar Madan

Associate Professor

Production Engineering Department,

DTU (formerly Delhi College of Engineering)

Delhi-110042, India

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List of Abbreviations

A.C.R.	Annual Confidential Report
A.P.	Assistant Professor
AHP	Analytical Hierarchy Process
ANN	Artificial Neural Network
ATL	Attitude towards learning
B.E.	Bachelor of Engineering
BOG	Board of Governors
BPR	Business Process Reengineering
C.R.	Confidential Report
CAT	Common Admission Test
CBP	College Building and Premises
CEE	Common Entrance Examination
CGPA	Cumulative Grade Point Average
CL	Centre Line
COSM	Cleanliness, Orderliness, Systematic and Methodical
CR	Consistency Ratio
DEA	Data envelopment analysis
EDP	Entrepreneurial Development Programme
Fbd.	Faridabad
FQ	Faculty Quality
GATE	Graduate Aptitude Test in Engineering
GCS	Good Communication Skills of Faculty
GMAT	Graduate Management Admission Test
GRE	Graduate Record Exam
HE	Higher Education
HMF	Hostel and Mess Facility
HOD	Head of Department
HOQ	House of Quality
I.C.C.	Industrial Consultancy Centres
ISM	Interpretive Structural Modeling
L.	Lecturer
LCL	Lower Control Limit
M.E.	Master of Engineering
MATLAB	Matrix Laboratory
MLPs	Multilayer Perceptions
MSE	Mean Square Error

NCR	National Capital Region
NPD	New Product Development
NSF	National Science Foundation
PE	Processing Elements
PG	Post Graduate
QC	Quality Control
QFD	Quality Function Deployment
R&D	Research & Development
SPC	Statistical Process Control
SQ	Student Quality
SSCE	Senior Secondary Certificate Examination
TEQ-AA	Technical Educational Quality Assurance and Assessment
TES	Technical Education System
TFD	Training for Faculty Development
TOL	Test on Line
TQC	Total Quality Control
TQM	Total Quality Management
TVE	Technical and Vocational Education
UCL	Upper Control Limit
UG	Under Graduate
WE LC	Well –Equipped labs and Classrooms

Chapter 1

Introduction

1.1 Introduction

Quality education is an absolute necessity at every level of society. Parents are interested to enroll their children in the best college/institute in order to provide them quality education at reasonable costs. Boards of trustees and management are interested to hire committed, laborious teaching staff so that quality of education can be improved constantly. But they also want to minimize the operational expenditure on the institute. Government wants to see taxpayer's money spent on education wisely and most efficiently. The interdisciplinary and multicultural space, field of interference of the main ideas of knowledge, the Indian Universities must offer the human communities models and landmarks regarding quality management. Thus there is need for universities to prove by this new curricular reform the aspiration toward the achievement of quality at the level of higher standards.

Technical Education is an integral part of the Higher Education System. The target for the "change" to prepare the Knowledge society in the social, economic and technical field is to give to the University an important role in the development of the community with new standards of quality. Technical Universities must offer the human communities models and landmarks regarding quality management. Thus there is a need for universities to prove this by reforming the curriculum with aspiration towards the achievement of quality. Thus, the Quality of Higher Education has become a public preoccupation under full process of harmonization at Global level and the quality management of education has become a priority. The general policy of the Technical Universities is focused on continuous improvement of the educational and research process that has developed within the departments as well as the formation of competent and competitive specialists, capable to respond to the demands of a modern society.

This educational policy has the following basic principles:

- The compatibility of the curriculum of specialties with the standards of Global education.
- The harmonization of the offer of specialties with the demands of the labor market and with the new directions of society's development.
- The continuous improvement of the university's offer, through development of a performing system of communication with students and foreign partners;

- The appropriation of resources designated to the improvement of the quality of didactic and research processes.

Education depends on several mechanisms. A technical education system (TES) or process consists of three different stages, such as input, process and the output with a feedback mechanism which makes it a closed loop (fig.1.1).

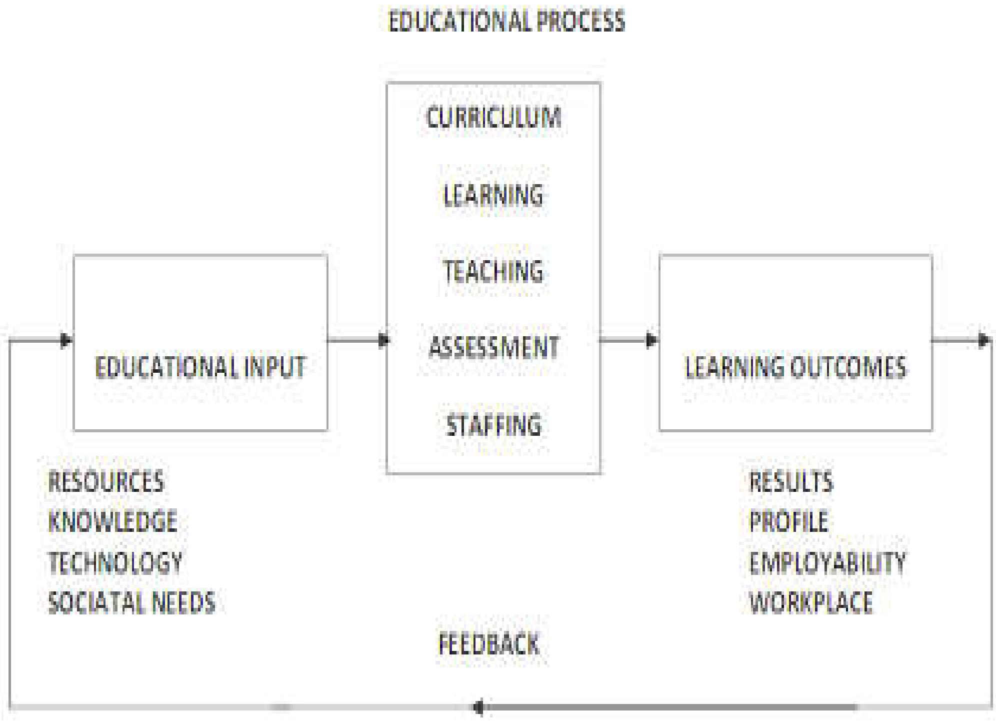


Figure 1.1 Block Diagram of Educational Cycle

The feedback coming from the output can be utilized to assess and improve the quality of a TES.

The main stakeholders of any TES are faculty, students, management and the infrastructure, which are responsible for efficient functioning of a TES.

Service quality may be viewed from three perspectives: the performance of the product, behavior of service provider's personnel and attitude of customers. The diverse viewpoint of service quality and its intangibility characteristic leads one to express service quality as the difference between customer expectations (before delivery of service) and perceptions (after delivery of service). A positive difference (or gap) implies that expectations are greater than performance, *i.e.*, perceived quality is less than satisfactory, leading to occurrence of dissatisfaction of the customer. In an organizational context, any effective quality control programme focuses on the identification of areas having large gaps so that efforts can be made to minimize the gap to obtain a competitive edge over competitors. Among all service sectors, the education sector, particularly the Technical Education System (TES), has direct bearing on society for society's growth and socio-economic development. One of the key skills required of an engineer is the ability to produce systems that satisfy users' requirements by correct selection, configuration, integration, operation and control of proprietary building blocks. In India, the fact was realized quite early and the impulse to create centers of technical training came long ago. Today, many engineering colleges and technical universities with different courses in undergraduate, postgraduate and research levels are in existence and compete with each other as well as with the foreign institutes for imparting education. The limited number of state-funded institutions and diminishing funding in higher education from the government caused the mushrooming of private institutions in India. Therefore, the students have a wide range of options to choose from which the institution to pursue their interests. As the students bear the complete expenditure of education, they deserve the best education. Therefore, quality has become a competitive weapon for the institutions to serve and attract their primary customers (students).

To this end, the development of a quality measurement instrument for the educational set-up and a methodology for the assessment of quality is of prime importance for providing guidelines to the administrators of the institutions. The quality indicators must satisfy all the stakeholders involved in the system. In an educational set-up, multiple stakeholders, *viz*. students, alumni, parents, recruiters, faculties, supporting staff, government, society and administrators, interact with the system in different ways and have diverse expectations. Therefore, the service items are likely to differ amongst stakeholders. The administrators of the educational set-up find it very difficult to fix the norms that would suit all the stakeholders.

1.2 The Nature and Scope of Quality

The corporate sector has universally recognized the importance of quality in their products and services for achieving and sustaining competitiveness. The engineering education sector has been slow to act. We must recognize the role of quality in achieving our identified mission and vision. What quality is and what it is not. Quality is very specific; it involves continuous improvement; it can be achieved by prevention; it implies zero defects or errors; it includes correction of errors. . Quality is not something vague; not something achieved by inspection, testing and checking; nor acceptable quality levels. . The scope of quality includes manufacturing activities, business processes, and services, and focuses on the needs of both external and internal customers. Perceptions of quality in higher education Quality perceptions depend to a large extent on the particular sector or group that is considered. Few such perceptions are indicated below:

- National Funding Agencies: education for largest number at minimum cost
- Educational Administrators: image and reputation of their institutions

- Faculty: student learning and satisfaction
- Barnett's classification Barnett has classified quality perceptions into three groups:
- Objectivist perception: identification and quantification of inputs and outputs. Inputs: faculty, physical resources, students, funds; outputs: student learning, failure rates, results, employment patterns, PG education, R&D.
- Relativist perception: examination of `fitness for purpose'. Different stakeholders have different
- Foci: students' educational process; employers' work output of graduates; professors' research.
- Development perception: exists within the institution, not imposed from outside.

TQM culture promotes achievement of quality through this approach Characteristics of quality applicable to services the major developments in quality control and assurance have taken place in the context of the manufacturing sector. Recently, these concepts have also been made applicable to the service sector, which includes the education sub-sector.

Some of the characteristics of quality applicable

- Responsiveness to customer
- Cost-sensitivity
- Volume-sensitivity
- Ethical considerations
- Energetic and enthusiastic approach
- Openness to experiment
- Goal/results focus
- Errors cannot be hidden
- Skill- not capital-intensive nature
- Heavy investment in training

1.3 Implications of TQM for engineering education of the future(105),(106)

The US National Science Foundation (NSF) task force on TQM has come up with the following definition of Quality Engineering Education:

`Quality Engineering Education is the development of intellectual skills and knowledge that will equip graduates to contribute to society through productive and satisfying engineering careers as innovators, decision-makers and leaders in the global economy of the twenty-first century.' Quality Engineering Education demands a process of continuous improvement of and dramatic innovation in student, employer and societal satisfaction by systematically and collectively evaluating and refining the system, practices and culture of engineering education institutions.'

The task force points out that TQM are not a destination, but rather a journey to improvement. The task force has also examined the nature of the customer of engineering education. It preferred to deal with the concept of `stakeholders', which could vary widely depending on an institution's mission, goals, strategies and tactics. The stakeholders include suppliers, such as high schools, and receivers, such as employers and students. Some indicators of academic quality summarize some salient indicators of student, faculty and institutional quality.

1.4 Technical Courses Relevant to Industry

All these years the Technical Education Institutes in the country have been working and developing without interacting with the Industry. The Industries have also so for not taken any interest in the relevant development of the course/infrastructure of technical institute. The Course curriculum must be designed keeping the requirements of industries in mind and be updated regularly as per the needs of the industries. The Courses should be more project oriented so that students may get more practical and implementation exposure.

Some of the advance engineering colleges in the world including a few a top technical institutes in India there is a culture of Industry training of student for a year or 6 months in between their courses, which really fills the gap between industries and academics. Merely doing few weeks of industry training or just managing such a training certificate at the end of the course for getting the degree does not serve the exact purpose of Industrial training concept.

1.5 Industry-Institute Interactions

Engineering institutions and industries need to combine in order to enrich and enhance the human resources. Most of the professions, if not all, have theoretical foundations. This theoretical base would enable the individual to optimize his contributions in the chosen field, thereby generating incremental value to the job and in the process enhancing one's own advancement along with the vertical axis of the organizational hierarchy. This advancement would naturally have the spin-off effect and efficacy of creating better prospects and gains from the individual while having consequent benefits to the organization. The process as envisaged above would bring into line the aims, aspirations and objectives of organizations and individuals.
In the present scenario, the nation is witnessing a major change in the approach towards business, industry and technology. Dynamics of competition and at the same time, complexity of industry as well as the sophisticated technological innovations of tomorrow demand continuing improvement in the quality of technical education and so that of technical institutions. Now, engineering has become a profession which young boys and girls are proud to join and get trained for various level positions. The

engineering education has proliferated into a series of courses across the length and breadth of the country, offering technical courses of specialized nature leading to diploma, degree, post-graduate and doctoral level programmes.

The interaction between industry and technical education is so crucial and grave that the relevant quality and cost-effectiveness are to be affected under the increasing pressure of the global competition. We are today surrounded with fast emerging technological innovations and therefore, without the Industry-Technical Education interaction, research and development activities would be quite irrelevant. The industrial sectors must be encouraged to enhance and pour their investments on researches undertaken by the high-level technical institutes in addition to their own R&D divisions which take care of their day-to-day quality control. In developed countries, the Government and industry are increasingly aware of their key human resources and propel to boost up their technical expertise.

In the present era of fast developing technology, it is imperative on the part of the industries to keep up their engineers and technologists in a steadily updating process. It is quite evident that a particular industry will essentially develop educational programme mostly suited and designed to its own requirements and hence, the concept of in-house education programme benefits the industry but suffers from the defect of being quite narrow- based. The technical institutions of excellence in our country may provide proper training facilities with regards to emerging technologies. The industrial houses do not still keep much interaction with the exception of a few.

It is, therefore, felt that technical manpower needs be identified and programme for educational and training facilities be built up in tune with the industries. The quality improvement programme for engineers and requirement- oriented research shall be promoted. The funds required may be met by the users of technical manpower by paying excess on their profit to support technical education. To facilitate the interaction with industries, some technical institutions have set up Industrial Consultancy Centres (I.C.C.). The strong interaction linkage policy may help the technical institutions in procuring financial support for their research activities, financial returns from commercial application of their outcomes and to work as indicator of ensuing technological innovations and to guide in framing the curriculum whereas the industries shall be benefited by obtaining reliable and cost-effective solutions to their problems.

1.6 Quality as Applied to Education

Quality is an attitude best defined not by the system manager but by those the system serves i.e. customers. Various definitions of quality are:

- Deming (2) defines quality as meeting and exceeding the customer's needs and expectations-and then continuing to improve.
- Juran (3) defines it as fitness for use-does it fit the customer?

- The American Society for Quality Control states that: “quality is the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs”.

The four components of quality are:

1. Quality is defined by the customer.
2. Quality is tied to customer needs and expectations.
3. Quality can have several dimensions of customer satisfaction-meeting, exceeding, delighting.
4. Customers’ needs and expectations change over time.

1.7 Examining the Dimension of Quality

Helping a group to understand quality can be accomplished by asking each individual to list what quality means to him or her. Then establish small groups, and ask each group to determine the five to seven most frequently mentioned components of quality. Next, merge the groups, and ask them to identify a total of five to seven characteristics of quality. Finally, compare the group list with the dimensions of quality as defined by the American Society for Quality Control.

1.8 Factors Affecting Quality in Engineering Educational Institutions

1.8.1 Large Scale Expansion

The large scale expansion has affected the availability of efficient faculty and infra-structure facilities especially well equipped laboratories, library, computer usage facilities, and group activities amongst many others. This has adversely affected, the inter- personal interactions between students, teaching staff and management, Notwithstanding the above, problems should not allow compromise on strict quality assurance system and lowering of valuation standard. This can be achieved by leadership where in the head of institutions and the management creates clear quality values and executes them through well designed systems and processes and also by giving greater autonomy to the institutions in managing the quality standards.

1.8.2 Interaction with Industries/Research Labs

As there is little interaction with industries/ research labs, there is a widening gap between knowledge/ information designed to be imparted to the students and what is required by employing industries. Further, the rapid growth in the knowledge and technology makes the technical curriculum obsolete quickly.

Therefore educational institutions and industries should maintain close contacts and inter-academia partnership programs be prepared and imparted.

In order to achieve reliable measure of quality, the level and quantum of employment needs to be normalized and standardized. One of the suggested measures is to exclude the top fifteen percent who acquire the knowledge and excellence through self motivation and their achievement is not influenced by the quality level of the institute. Also exclude bottom fifteen percent who will consist of extremely weak students for whom nothing can be contributed by the institute. Thus the performance of remaining seventy percent should be considered for aggregating the quality level of the institutions.

1.8.3 Proper Monitoring System

Every institution has its own systems of monitoring the quality of education being imparted and most of these are theoretical in nature and not result based and also goal based. The system should be specific; result oriented and should clearly indicate the quality of students graduating/post graduating, faculty expertise and the overall quality of institution. The quality of institution can be measured in terms of percentage of out-going students in gaining employment and building strong career path.

1.9 Major Thrust Areas to Improve the Quality of Technical Institution

An institute always takes care of the quality of the institute so that the desired goals should be achieved. There are many areas of concern which has to be monitored in order to improve the quality of technical education. Some of the important factors have been given below.

1.9.1 Students Quality

- Qualifications and merits of the entering students.
- Fraction engaging in undergraduate research.
- Fraction completing graduation as per the university or govt. norms.

1.9.2 Faculty Quality

- Faculty expertise
- Adequacy of subject teacher
- Effective classroom management

1.9.3 Management Inputs

The lack of adequate inputs by the management and non provision of qualified, well paid and professional faculty adversely affects the quality of technical education. Some of the major points to be considered by the management are as follows:

- Training for Faculty Development
- Timely Assessment of Faculty and Students
- Library Standards
- Adaptability to modern techniques.

1.9.4 Infrastructure in an Institution

- Provide Well-equipped laboratories with modern facilities.
- Cleanliness, orderliness, systematic and methodical of the institute
- College building and premises
- Hostel and Mess facility

1.9.5 Accountability

- The assessment that prevails at present is the ritual system of confidential reports (C.R.) and A.C.R.
- This has either remained a formality or used as a stick by the management.
- Thus the teaching profession is left without any meaningful independent and comprehensive grading system. Further , there is no encompassing perspective of the entire institution including students, staff, faculty and management by way of grading the institution as a whole and both faculty and management being accountable to public, state and financial institutions.
- There is therefore, a need to institute actions to design a system for the accountability and bringing sense of professionalism. The system should ensure removal of overlapping of responsibilities, authority and roles and of cumbersome administrative procedures.

1.10 Quality Criterion in Education

Among multiple meanings of the term "quality", two have a critical importance for the improvement of quality:

a. "Quality" means those characteristics of processes that satisfy the needs of customers and thus ensure their satisfaction. In this sense, the significance of quality is oriented toward income. The purpose of such higher quality is to ensure a greater satisfaction of clients and, separately, to increase incomes

b. "Quality" means lack of deficiencies – lack of such errors those results in exploitation accident, non satisfaction of customers, claims of customers, etc. toward costs.

In education, quality means good academic culture, excellent academic results, progressive and adaptive management, clean administration and prominent profile of outgoing students. It involves the expectations and perceptions of students, faculty, supporting staff, administrators, parents of the students, government, industry (recruiters) and society etc. They interact with the system in different ways and their objectives may be different. So the implementation of a quality improvement programme necessitates the identification of various factors in an educational set-up and determination of their criticality. Sometimes the stakeholders are classified into three groups: input, transformation and output. Students and parents are included in input stakeholders, the faculty is the transformation stakeholders and the corporations and society are the output stakeholders). The main objective of a TES is the development of methodologies for improving the quality of education and establishment of a new brand of their own.

The education sector, particularly the Technical Education System (TES), has direct bearing on society for society's growth and socio-economic development. One of the key skills required of an engineer is the ability to produce systems that satisfy users' requirements by correct selection, configuration, integration, operation and control of proprietary building blocks. Among the limited number of state-funded institutions and the mushrooming of private institutions, quality has become a competitive weapon for the institutions to serve and attract their primary customers (students). Some of the important parameters for quality in education are as follows:

- Training on state-of-the-art technology, Comprehensive learning resources, Opportunities for campus training & placement, Close supervision of students' work, Expertise in subjects and well-organized lectures, Good communication skill of academic staff, Well-equipped laboratories with modern facilities, Design of course structure based on job requirements, Encouragement for sports, games and cultural activities, Cleanliness, orderliness, systematic and methodical, Available regularly for students' consultation, Effective classroom management, Recognition of the students, Adaptability to modern techniques. These factors have been considered further in following analysis.

In India, students are required to pass Primary Education and passing a prescribed National Common Entrance Examination. A student study Secondary School at the end of which he or she takes the Intermediate Exam, also known as the Senior Secondary Certificate Examination (SSCE) or the Ordinary Level Exams. Mathematics and English Language being compulsory. Three possible grades are obtainable for each subject; these are first class, second class, third class and fail.

Before a candidate can be admitted into any university, he/she is expected to pass, some number of relevant subjects including Mathematics and English Language in the Intermediate Certificate Examinations. A second admission requirement is the Common Entrance Examination. The CEE process involves the implementation of cut-off. The admission process involves the implementation of cut-off marks and certificate requirements. However it has been observed that desperate candidates are able to manipulate the system. It has become obvious that the present process is not adequate for selecting potentially good students. Hence there is the need to improve on the sophistication of the entire system in order to preserve the high integrity and it should be noted that this feeling of uneasiness of stakeholders about the traditional admission system, which is not peculiar to India, has been an age long and global problem.

1.11 Review of Problems Related to Examinations in Technical Education

➢ Admission Policy

1. Wide variation in admission policies adopted by various technical institutions resulting in great variation in the quality of students admitted.
2. Some institutions admit students on the basis of common entrance test of high standard on all India basis, while other colleges admit students on the basis of marks obtained in the qualifying examinations conducted by various state boards having variations in their course structure, teaching process and examination system.
3. Also, cut off marks for admission fixed by various state governments are different and keep on changing every year. The situation is further worsened by reservation policies adopted by various State Governments and Central Government.
4. The net result is that students of very poor merit get access to technical institutions along with good students and make academic environment unhealthy, which has an adverse impact on the quality of technical education.
5. Poor quality students lack discipline, interest in studies and zeal to work hard, which are the most important prerequisites for any higher education. Their indifference to studies not only de-motivates other meritorious students but also teachers to a great extent.
6. In view of the above, it is extremely important to revise admission policy to ensure that only such students are admitted to technical institutions that have the potential to take up the load of engineering education.

➢ Teaching Process

Teaching process is managed entirely by faculty with the help of various inputs like syllabi, laboratories, library, computing facilities and industry interaction.

1. Besides teaching work, faculty members are also involved in other activities like curriculum development, laboratory development, and examinations. Thus, faculty is the most important input to an institution.
2. Due to proliferation of technical institutions in the country, demand for faculty has gone up excessively. Acute shortage of well qualified faculty forces the management to appoint even fresh engineering graduates as faculty who are required to engage classes immediately after joining the institution without being given any training and preparation time.
3. This causes the decline in quality of teaching in these technical institutions. Poor quality teachers and poor quality students form very good team and jointly encourage indiscipline and bad work culture in the institution.

- ## **Examination Process**

This process aims at measuring the degree of knowledge assimilated by the students during a course of study or training imparted to them.

1. In technical education special emphasis is given to continuous evaluation of students' performance during a term or academic session.
2. Examination process has suffered great set back in achieving its objectives on account of various reasons resulting in a assessment that in many cases does not reflect the true level of knowledge acquired by the students.
3. It has been observed that students may pass examinations securing good marks with scanty preparation, mostly done just before the examination. This illustrates the quality problem in the present examination system.

1.12 Suggested Remedies to the Quality Problems in Technical Education

Total Quality Management (TQM) approach is an effective but long term measure for transforming the minds of people engaged in technical education towards providing quality education. Few other measures enlisted below will also help in improving quality of technical education.

i) Change in admission policy to improve the quality of students to be admitted in the institutes.
ii) Appointment and retention of qualified, experienced, and competent faculty members.
iii) Quality improvement of junior faculty members.
iv) Improvement in institutional infrastructure.
v) Improvement in teaching methodology.
vi) More emphasis on laboratory work.
vii) Revision of curricula to make it more relevant to current needs.
viii) Development of research culture in the institute.
ix) Strengthening interaction with industry.
x) Examination system reforms.
xi) Increasing Technical Teachers Training Institutes.

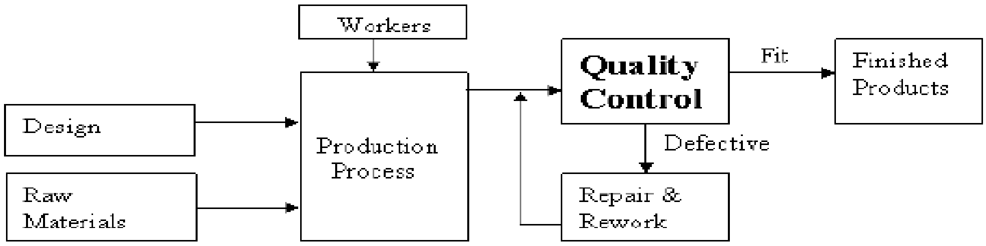
Table 1.1 Comparison of 6 Sigma with Industries

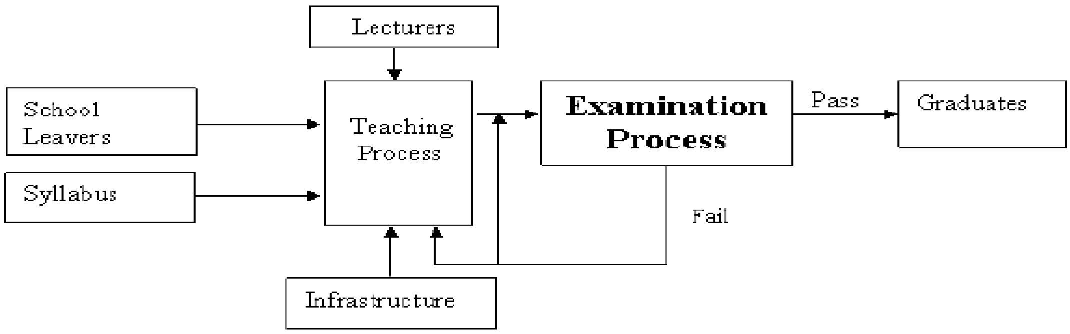
Professionals in Industries	**Professionals in Education**
Leadership Group Council 1. Senior manager they plan & execute 6 sigma plans. 2. Their aim is to achieve 6 sigma in a planned way.	Dean /Management representative/Chairman of BOG 1. Member of Management Committee. 2. Proposes the Six Sigma plan to management.
Project sponsor & champions 1. A senior manager with an experience in 6 sigma projects. Accountable to leadership. 2. Council for success of projects.	Principal 1. Sets up a goal for improving project. 2. Coaches and approves changes in team charter. 3. Finds resources for teams. 4. Advocates for the team efforts in Mgmt.
Six Sigma Coach (Master Black Belt) 1. The 6 sigma coach provides expert advice to 6 sigma improvement teams 2. They act as a mentor & trainer.	HOD's 1. Communication with principal and management 2. Deals with resistance to implement 6 sigma. 3. Helps to resolve team & other conflicts 4. Gather & analyzes data about team activities.
Team Leader/Project Leader (Black Belt) 1. The Team leader accepts primary responsibility of result of 6 sigma project. 2. They are specified to one team only.	Professor In charge/Chair Person 1. Reviews/revises/clarifies the project. 2. Work with team members. 3. Select the project team members. 4. Identifies & finds resources for the team. 5. Documents final project result.

Team Members (Green Belt)	Student Advisory committee
1. The team members bring the brain and measure for collection & analysis of data needed to improve the process.	1. Carries out instruction for data collection and analysis. 2. Carries out assignments. 3. Reviews the efforts of team itself. 4. Learn new data-driven ways to manage the operation
Process owner 1. The process owner is normally the manager of a part of a particular function. 2. They receive solution created by an improvement team and become the "owners" responsible for managing the improved process.	Process Owner 1. All faculty members, HODs & staff of the technical institute. 2. They are responsible for continuous improvement & maintenance of the same

1.13 Role of Examination System in Technical Education

1. A strict and flawless examination system in an institution or university screens out good students who have attained requisite standards of learning from the rest.
2. In addition, it automatically creates a pressure on other subsystems and processes of technical education, i.e., teaching, infrastructure development, faulty performance improvement, and process of admission in case of high failure rates of the students.
3. It is similar to a quality control (QC) department whose main function is to collect samples of manufactured units as per pre decided sampling plan and to measure various characteristics and attributes of the items for comparing them with the established standards. Products meeting the prescribed standards are certified as FIT and sent to market as finished products while those not meeting the standards are classified as DEFECTIVES which are sent back to production department for repair and rework. After rework, these items are again sent to QC department for certification.
4. The QC department also analyses the root cause for the production of DEFECTIVES and recommends corrective actions for improvement in material quality and process quality. Similar is the function of Examination System in the field of Education.





1.14 Some Criteria Adopted for Ranking Academic Quality (99),(107):

There are several agencies and magazines that undertake the task of ranking academic institutions Country-wise, region-wise and globally. Most of these published rankings indicate the criteria employed; they assign weighting factors to the different criteria and come up with a single composite numerical score. Some of these criteria are:

- Depth and nature of coursework
- Student/faculty ratio
- Selectivity or acceptance rate: number of applications per seat
- Number of enrolled students who graduate (`retention')
- Students' later achievements
- Library facilities
- Laboratory facilities
- Computing facilities
- Reputation/prestige
- Quality of faculty members
- Performance in competitive exams (GATE, CAT, GRE, GMAT, etc.)
- Accomplishments of alumni
- Endowments
- Institutional resources
- Perception of employers
- Productivity research, consultancy.

Following recommendations in order to ensure that the rankings reflect a valid indication of relative academic quality:

- The assessment must be multidimensional; based on many measurable aspects.
- Measures should be based on achievements of majority of faculty and students.
- Must be based on per capita figures; not aggregate numbers.
- A technique must be devised to measure how much students learn; the value addition achieved.

In a very recent ranking of universities and technical institutions in the Asia-Pacific region

Published by Asia week, the following criteria were employed:

- Academic reputation
- Student selectivity
- Faculty resources
- Research output
- Financial resources.

No system of quality assessment is perfect. Following are some of the criticisms of commonly employed criteria:

- Number of Ph.D. holders on faculty: not every Ph.D. holder is a good teacher; senior professors may not teach UG classes at all.
- Number of enrolled students who graduate: college may screen out low-performers.
- Number of research papers: assumes all papers are of equal importance; focus should be on quality, not quantity.
- Productivity in terms of research, consultancy, sponsored research.
- How to quantify student counseling, good teaching, etc.
- Reputation rankings: perceptions of quality are highly subjective.

1.15 Motivation for research

Some of the factors which motivated me to undertake the subject research work are as under:

- Due to globalization we need more and more technical manpower of high quality in the industries, research centers and institutions.
- The number of the technical institutions is increasing exponentially under the govt. efforts of liberalization and reform of higher technical education to make India the largest English speaking technical manpower of the world.
- Industry is becoming more competitive locally as well as globally and for that we need higher number of technical manpower at all levels. For this improvement in the quality of TE is must and is a need of hour.
- The rapid growth in the knowledge and technology makes the technical curriculum obsolete quickly. Therefore, technical institutions, industries and

research centers need to maintain close contacts, inter-academia partnership and higher quality standards in technical education.

- Under the present scenario and for the reasons already stated, a lot of sub-standard technical institutions have already come up and many are in the pipeline to get established.
- These institutes are merely producing technical graduates who do not meet the expectations of the industries.
- Further there is greater amount of technical students and professionals across national borders making it imperative and concerned agencies not to be restricted to national considerations only. Therefore, high quality standards have to cater for global processes of internationalism in TE.
- However, at present very little amount of research work seems to have taken place in this field.

Chapter 2

Literature Review

2.1 Introduction

In this Chapter, a survey on the work done in the field of technical education has been discussed. It gives the research carried on various aspects of technical education. In this chapter a survey is given regarding various factors which are there in technical education and also the factors that affect the quality of technical education. This chapter gives an overview of the researches that have been done by various researchers on various factors that affects quality control in technical education. It also gives the techniques which have been applied for quality assurance, quality assessment and quality control in technical education. It also gives the recent developments being done in this field.

2.2 History

In 1962, Ainslie W. G (4) said that the changes in technical education are so far-reaching that industrialists should appreciate the implications. He gave an outline of the general educational system and suggested some changes in the structure of the technical courses. In 1976, Underwood W.J. (5) made an extensive study on methods on which engineers rely on to remain technically viable. Factors make it difficult for engineers to remain technically viable and suggested changes in our in-house education program that would be helpful to them. After his study he gave a list of various factors and arranged them in ascending order of preference. Liang Z., (6) in 1991 considered that there are two major types of problems: continuity of knowledge, and consistent requirements on students. He applied TQM technique for quality control and suggested methods for TQC in teaching. Swain P.H. and Alef E.R. of General Motor Corp. in 1991 (7) predicted that quality of technical education improves by integrating university and industries. They showed this by enrollment of engineers in a course started by Purdue University and General Motor Corp. resulted in making the engineers to maintain their technical competence and earn academic and professional advancement. Kalley G.S. in 1991 (8) gave a research which showed the difficulties in applying TQM technique for quality control in education and also concluded the need of such techniques of proper quality control in education. In 1994, Jaraiedi M. and Ritz D. (9) gave a methodology using Quality Function Deployment (QFD) as a tool to explore some key elements of higher education. QFD procedures and forms were used to analyze and scrutinize the specific areas of advising and teaching within the university. Recommendations were devised which range from a comprehensive instructor-training programme to self-help and mentor programmes by student groups.

The period of 1990s represents the initiation of major moves towards managerial change in technical education. In the two distinct sectors – Universities and Further Education establishments – quality was managed in a control sense, as a means of ensuring the basic standards. Their approaches to management of quality were unique (Becher et al., 1978) (10). The further education sector, typified by Polytechnics or Community Colleges, met the community needs in the practice of various trades. An inspectorate carried out periodic inspections of academic functions, much on the lines of contemporary industry practice, which was deemed sufficient to meet quality requirements. The direct consequence of this was a steady loss of motivation to improve quality (Becher et al. (1978, p. 133) (10) described inspection as "change inhibitor"). But in spite of the similar emphasis on inspection, there were very substantial differences between industry's and further education's approach quality control. In industry, the controllers were a part of the establishment, to "assure" the fault free functioning of the products. Whereas, despite the regularity of inspections, the inspectorate remained a government arm and educational institutions never established quality control units (Becher et al., 1978, pp. 137-40) (11).

The academic freedom was considered sacrosanct, and quality control was only a marginal aspect of further education. In the same vein, universities asserted their academic freedom even further and there was no provision for any external inspection, except for some formal reporting mechanisms (Bird in Shattock, 1996 (12), pp. 253-4). Thus, the attitude of the technical education institutions was characterised by a strong aspiration for autonomy, even in the face formal inspection procedures of the government. To the institutions quality was only meaningful in the context of academic freedom. Meanwhile, with the surge in demand for workers in the "knowledge economy" in 1980s, the artificial distinctions in the binary system of technical education began to breakdown, and in early 1990s further education sector assumed an equal status with universities, marking the beginning of an integrated technical education sector. In improving the quality of education and training institutions, notions such as "competition", "efficiency", "effectiveness", and "excellence" have been introduced. In 1995, Samuel K. Ho and Katrina Wearn (13) developed a TQM excellence (HETQMEX) model for higher education and training based on fundamental concepts of service quality: 5-S, marketing and education quality control, quality control circles, ISO 9000 and total preventive maintenance. The article suggested that commitment from everyone, competence and continuous improvement as solutions to some significant problems encountered in implementing TQM in technical education. Clive Colling and Lee Harvey

(14) discussed the different forms of external enquiry into the operations of HEIs that constitute existing quality control, assurance and assessment processes and procedures. They proposed that external scrutiny of operations should adopt an approach that ensures accountability, enhances quality, is practical, efficient, and effective and offers a degree of autonomy. In 1998, Erika Martens, Michael Prosser (15) gave a case study of the La Trobe University who developed and implemented a university-wide system of quality assurance that ensures that each subject is systematically reviewed and enhanced by those teaching in the subject. While it incorporates compulsory student evaluation of teaching of each subject the result of this student evaluation is not the focus of the quality assurance system. The focus is on ensuring that those teaching the subject reflect on and make recommendations for further improvement of the subject. K. W. M. Siu (16) gave a study of evaluation of engineering and technology education from a social and cultural viewpoint and suggested that the evaluation should aim to be sensitive to local traditions and histories, and to particular wants, needs and fancies. He concluded that a reliable and quality evaluation system is important for our technical education system. 'Reliable' does not simply imply using a tight and rational approach, or a globally-adapted evaluation rule. Jan McKay and David Kember (17) studied and gave the limitations and powers of quality assurance and shows that it is most effective when operating in concert with educational development processes. He concluded that there is a need to determine whether appropriate educational or staff development support is needed. An appropriate development programme may be needed if the recommendations of the quality control process are to be implemented. Dr Bernardo F Adiviso (18) gave the basic concepts of TQM and provided pointers for evolving TQM managed institutions in Technical and Vocational Education (TVE). Haji Zakaria bin Yahya (19) highlighted the need to develop the entrepreneurial skills in Vocational and Technical Institutions, using the Entrepreneurial Development Programme (EDP). Three stages of EDP were explored: the awareness stage, the exploratory stage and the start-up stage. This paper also makes certain recommendations for a successful EDP - one of them is to integrate EDP in the school curriculum. Haji Mohd Daud Bin Haji Mahmud (20) showed the impact of dynamic technological changes, especially in communication technology, computer technology, information technology, the introduction multi-dimensional delivery systems such as the web-based instruction, satellites, open learning, distance education and lifelong learning, and the era globalisation, have changed the traditional role of teachers as the undisputed master of the teaching profession. The traditional classroom has also shifted a different setting. He tried to look into the future knowledge id skills requirements of teachers based on the above changes.

Gulser Koksal and Alpay Egitman (1998) (21) employed quality function deployment (QFD) approach to improve industrial engineering (IE) education quality at the Middle East Technical University (METU). They found that the major stakeholders of Technical education are students, faculty members and future employers of the students. The requirements of these groups from an IE graduate are determined by surveys and interviews with them. These requirements are prioritized. Main education requirements are identified to meet the stakeholders requirements. Finally, they gave results and plans for future studies. They also found that the usage of AHP (analytical hierarchy process) and the geometric mean process enabled better handling of different stakeholder groups in the prioritization of their requirements. Their study provided a strong initiative in considering teaching and counseling, and curriculum design for improvement. It has also been observed that the awareness of quality has increased, and communication has improved in the department, also industry-department relations have been enhanced. Students have appreciated that they have roles in quality improvement. As a result, motivation of students has increased. Karapetrovic and Rajamani (22) described a method for monitoring the quality of teaching and learning outcomes in a course (Introductory Engineering Economics) taught in the classroom. Data came from questionnaires which contained 3to 5 questions with multiple choice answers, one possible answer was' don't know' Students were asked to answer the questions at the beginning of the lecture to check if they had prior knowledge of the topic to be covered in the classroom. Students were again asked to answer the same questions at the end of the lecture. This provided a measure of knowledge gain. The statistics of 'knowledge gain' obtained was plotted against question number on a traditional 'p' control chart. On the basis of trends of points on the chart, in-control and out-of control situation of classroom teaching and learning process 'was determined Besterfield-Sacre et al.(23) described an application of SPC charts for monitoring enjoyment of math and science courses by first year engineering students. The data came from questionnaire where answers were based on a 5 point scale (e.g.,1="not satisfied" to 5="very satisfied"). For such data traditional "p" chart was not appropriate since the response did not fit into a "yes-no" category; and use of variable charts was not appropriate since the data were discrete rather than continuous and non-normally distributed. To address these issues, the authors used two alternative non-parametric control charts. The chi-square chart was based on "using the chi-square goodness-of –fit statistics to compare an actual distribution with theoretical distribution". The modified "p" chart was extension of a traditional "p" chart for more than two categories. For each data point, pre-survey responses used to establish the control and the post – survey responses were plotted. F. Craig Johnson and William A.J. Golomski (26) gave six quality concepts for education based on quality management principles in areas such as leadership, understanding stakeholders and involvement of people. Also lists some management concepts required to provide the necessary linkages for the improvement of education, including identification of critical processes for improvement, and reporting improvements in terms meaningful to process stakeholders. In the year 2000, Muhammad Z Mamun (27) analyzed a number of non-govt. universities and found out that Human Resource Development and Management, and Customer Focus and Satisfaction are factors which were leading to weak performance of the universities. He saw that they were doing moderate in the areas of Quality and Operational Results, Leadership, Information and Analysis. In the areas of Management of Process Quality, and Strategic Quality Planning the performance is a little better. Hence the universities can focus more on its human resources (e.g., faculty and staff development), highlighting customer needs (e.g., quality education, better library facility, laboratory facilities, internship assistance, etc.). Strong leadership is also found paramount important inefficient running of the universities. He applied TQM and found out various areas in which the universities are weak and gave an exact result and also suggested the areas to be taken care of for better performance.

From the early 1990s onwards the emphasis was shifted to formal assessments of quality in technical education to spur the institutions to adopt formal systems of quality management on the lines of businesses rather than the traditional loose regulation or indirect controls (Brennan and Shah, 2000). In comparison to the industry, in technical education sector there have been more strident criticisms of the theoretical compatibility of quality management to education. Hence in order to come up with a more effective model for Quality in Technical Education one has to carry out a renewed exploration around issues unique to quality in technical education (e.g. Kezar and Eckel, 2000).

2.3 New ERA of Quality Control in Technical Education

After the year 2000, quality in technical education became a very important aspect and a number of researches started in this field which led to a great development in this field. Quality became very important aspect that universities started doing at their individual level for self evaluation.

In 2001, Chandandeep Singh and Kuldeep Sareen (28) described Deming's cycle and its 14 points used to ensure the quality of technical education process. Deming's cycle is applied to the faculty members who are in direct contact with students. Deming's 14 points are revisited in context of technical education and are discussed how well can be applied into the classroom. He concluded that Deming's PDCA cycle is recommended for faculty members/teachers to improve the quality of teaching. Deming's 14 points are also revisited in context with technical education and are emphasized that teacher should lead for whole class in the drive for ever improving quality of every single activity by providing the proper encouragement, training, facilities and time. Manpreet Kaur et. al. (29) studied and gave some of the quality issues in technical institutions where implementation of ISO 9001:2000 may provide the management a frame work to continually improve the existing resources and process by setting up quality objectives, measurements etc. to achieve higher standards of quality in education. It describes the introduction to ISO 9001:2000 quality management standard, its interpretation with respect to technical institution activities, documentation requirements and implementation approach. Sangeeta Sahney et. al. (30) studied Indian educational institutes in terms of how well they meet the industry needs. They used quality function deployment (QFD), and a range of statistical techniques, to design and analyze a questionnaire which results in a clear demonstration of a lack of satisfaction. The analysis also identifies those factors which should be specifically addressed to improve quality and customer satisfaction. Angelo Tartaglia and Elena Tresso (2004) (31) developed a Web-based automatic evaluation system for students of engineering faculties. The system, named Test on Line (TOL) can verify the possession of ideas, the ability to combine them into deductions, and the capability to make simple numerical calculations for otherwise practical exercises.

XJAO-WA LI, JIAN-HUA ZHAO, BAO-HONG LI (32), gave several measuring mathematical models by using fuzzy set theories to evaluate the quality of management in universities and colleges by fixing portions among different factors. They developed models and used for assessing the universities. They models were based on fuzzy logic technique which were proven to be very effective and after programming it with computers would make it a very convenient and useful tool for quality control in technical education. Donev, V.S. and Barudov, (2004) (33) proposed a scientific model at their university for quality management of education.

The research in this field then just goes on increasing and led to new developments in this field.

2.4 Recent Developments and Research

After the tear 2005, there has been an exponential increase in the amount of research being done in the field of improving and increasing quality in technical education. Due to increase in the opening of new private technical institutions worldwide quality control in technical education has become a necessity. This has lead to an increase in the mathematical models, data analysis techniques, etc. which can be used to assess the quality in education.

K.Grygoryev and S. Karapetrovic (24) again presented a model for an going measurement of student knowledge gain as it occurs in classroom. This paper is an extension of previous work of Karapetrovic [24]. In this work same courses was taught by two instructors 'A' and 'B'. Instructor 'A' taught the course in fall and springs sessions,2002 and instructor 'B' taught the same course in fall session 2002.The statistics obtained was plotted on traditional 'p' control chart. Comparison was made in teaching and learning process of instructor 'A' and 'B'; further a comparison was made in teaching and learning process of instructor 'A 'for the two semesters. Jill Johnes (25) analyzed the teaching efficiency of the teachers using Data envelopment analysis (DEA) technique. The results suggested that efficiencies derived from DEAs performed at an aggregate level include both institution and individual components, and are therefore misleading. Thus the unit of analysis in a DEA is highly important. Moreover, an analysis at the individual level can give institutions insight into whether it is the students own efforts or the institutions efficiency which are a constraint on increased efficiency. This has implications for the choice of strategy for improving efficiency. Augustus E. Osseo-Asare, et. al. (34), said the leadership is one of the critical success factor for continuous enhancement of higher or technical education. He identified and categorizes leadership practices into weak, good, best, and excellent on the basis of efficiency and effectiveness of each practice in sustaining academic quality improvement. It provides a conceptual framework for improving weak leadership practices. He did this by employing an EFQM Excellence Model. This led to Academic quality planners to become more aware of the need to improve the tasks and activities constituting leadership processes. The emphasis on a structured approach to self-assessment of leadership performance has the potential to reverse the ranking of leadership second to processes in UK TEIs. Cecilia Temponi (2005) (35) analyze the main elements of continuous improvement (CI) in higher education and the concerns of academia's stakeholders in the implementation of such an approach. He found out that adoption of a CI approach in higher education requires not only upper administration commitment, but also uncovering the current underlying culture and examining the appropriateness of the objectives to adopt CI. A culture of a long-term commitment to CI implies engaging the, administrative and academic systems and all the stakeholders of the institution. This was identified as a major road-block for quality initiatives. Jitesh Thakkar, and Anil Shastree (2006) (36) used a quality function deployment (QFD) which prioritizes technical requirements and correlates them with various customers students requirements for the present Indian context. As an extension to the basic model of QFD house of quality (HOQ), the scope for futuristic improvements is explored through a four-phased QFD process. Challenges involved in the implementation of TQM are investigated using an approach of force field analysis. They Identified technical and students requirements for the modern educational set-up. They provided information about the severity of various technical requirements of competitive education. They recognized the need for continuous improvement, cultural change and effective use of financial resources to improve the value addition at each level. They developed an understanding of the issues to be addressed at each phase of TQM implementation. Thomas F. Edgar et. al., (2006) (37) discussed different academic and industrial viewpoints on the control course and suggest ways in which the control course can be renovated (a more positive image than reformed). The roles of simulation and laboratory experiments are highlighted and alternative ways of teaching control in the future are described, including problem-based learning, case studies, and use of multimedia classrooms.

Later in 2006, Roediger Voss and Thorsten Gruber (38) studied and gave an insight into the desired qualities of the lecturers. They indicated that the students want lecturers to be knowledgeable, enthusiastic, approachable, and friendly. Their study also indicated that students are mainly interested in vocational aspects of their studies and are less interested in the subject. These qualities were used to control and improve the quality of technical education. The research in this field carried on and in the year 2007, S. S. MAHAPATRA and M. S. KHAN (39) gave a measuring instrument known as EduQUAL for evaluation of quality in Technical Education System (TES). They carried out a Factor analysis on responses obtained through cross-sectional questionnaire survey on various items to validate dimensionality of the instrument and it is found that 28 items loaded above 0.5. Neural network models have been proposed to assess the degree of satisfaction of various stakeholders in TES. In doing so, not only the areas of improvement but also the minimum number of items satisfying all the stakeholders can be identified. Finally, the Quality Function Deployment (QFD) method is used to provide guidelines for administrators of the institutions to prioritize improvement policies needs to be implemented. Yau Tsai and Sue Beverton in (40) presented a study which concluded that top-down management through its exercise of direct power is still a preferable means of reducing the chaos resulting from teachers caught up in de-stabilizing and confusing change processes. In the current globalization context, it is also concluded that the success of top-down management is predicated upon a willingness or readiness of the faculty to allow it to exist. They said that the quality of technical education can be effectively controlled by the top to down management. A proper involvement of their powers can be really effective for quality control. Hartini Ahmad et. al., (41) examined the critical success factors of business process reengineering (BPR) in higher education (HE). They found seven factors to be critical to BPR implementation success. The factors are teamwork and quality culture, quality management system and satisfactory rewards, effective change management, less bureaucratic and participative, information technology/information system, effective project management and adequate financial resources.

P. Venkataram and Anandi Giridharan (1) designed a Technical Educational Quality Assurance and Assessment (TEQ-AA) System, which makes use of the information on the web and analyzes the standards of the institution. With the standards as anchors for definition, the institution is clearer about its present in order to plan better for its future and enhancing the level of educational quality. They tested and implemented the system on the technical educational Institutions in the Karnataka State which usually host their web pages for commercially advertising their technical education programs and their Institution objectives, policies, etc., for commercialization and for better reach-out to the students and faculty. This helps in assisting the students in selecting an institution for study and to assist in employment. S.S. Mahapatra and M.S. Khan (42) designed a measuring instrument known as EduQUAL and an integrative approach using neural networks for evaluating service quality is proposed. The dimensionality of EduQUAL is validated by factor analysis followed by varimax rotation. Four neural network models based on back-propagation algorithm are employed to predict quality in education for different stakeholders. The study demonstrated that the P-E gap model is found to be the best model for all the stakeholders. Sensitivity analysis of the best model for each stakeholder was carried out to appraise the robustness of the model. Finally, areas of improvement were suggested to the administrators of the institutions. Dr. Subrata Das and Dr. Anindya Ghosh (43) gave the importance of the need of quality control in technical education. They used ISO 9001:2000 and TQM technique for the evaluation of quality in textile education. Implementation of the above techniques resulted in the continual improvement in textile education.

Gitachari Srikanthan and John F. Dalrymple (44) developed a overarching basis to consider issues of quality in higher education. Their study discussed different approaches of management that can be synthesized of quality control in technical education. They provided a thought framework for addressing the quality issues in higher education they used techniques like ISO, TQM and QM.

Yousif Bahzad and Zahir Irani (45) developed a QA model for military institutions. The research seeks to assess, through a case study how newly established education institute such as Royal Command and Staff College (RCSC) adapt and assimilates quality assurance systems. Using action research techniques, this case study analyses continual conceptualization, implementation and evaluation of quality assurance actions over time. The cyclical process through time involves development of a model of quality assurance systems, implementation and evaluation. The study covers the period of the training years 2005/ 2006 to 2006/ 2007. Owing to the nature of this research and study of the complexity of organizational behavior and change with active intervention, a case study design is adopted. The research involves a triangulation of multiple research designs, methods and analysis, which comprise Action Research Group Process, Survey Instruments (questionnaires), and Focus Group Interviews. The study finds that a strategic model of quality implementation emerges as a response to the inputs from the dynamic environment, the aspects of which are particularly ascertained by the actions of committed instructors. C.M. Gheorghe, et al. (46) depicted the peculiarity of Quality Function Deployment method (QFD) applied to quality improvement in higher technical education. The application of this method has been adapted to the typical profile of the services researched. Moreover, it differs from the classical method on how the data on the client's needs has been gathered as well as on the way some data on competition has been missed out.

Ziren Wang and Ronghua Liang (47) used SPC (control charts) technique for quality control or improvement of technical education. To promote the teaching quality is one of the main objectives for colleges and universities in current period. Teaching means process. Factors which may cause abnormal for a teaching process are discussed herein. Applying of X -S chart and p chart to monitor the teaching process is discussed. A instance which how to use X -S chart and p chart to monitor average mark and fail rate is discussed. Applying of SPC is helpful to promote teaching quality. They concluded that the management and monitoring of teaching process should be enhanced, simultaneously, the SPC, which is widely used in enterprises' quality management and control, should be applied to monitor the teaching process, especially for those common basic courses, the SPC methodology is proven effective to find problems in a process, so that solutions to existed problems could be given in time, it's highly helpful to promote quality of teaching; it's highly necessary for quality engineering which carried out currently by colleges and universities. Lidia Cristea and Dan Gogoncea (48) applied fuzzy approach in quality management of higher education. They concluded that that the adoption of the fuzzy formalism is a possible solution to the standardization in the domain of quality, in which to the usual terms are still given various meanings by the managers of various firms, on markets that visibly oscillate between globalization and regionalization.

C. M. Bhatia and Smita Bhatia (2009) (49) said that the learning process of the higher technical education should be directed such that students and young faculty members are able to give their best; both in terms of intellectual content and skillful efforts. They analyzed the prevailing structure of the centers of higher technical education and suggests strategies to improve their performance. They also attempts to strengthen the importance of Participative Learning Pedagogy, with emphasis on the equal and interactive participation of student in teaching process, in conjunction with generic skills, well-trained faculty, well-equipped laboratories, good student centric learning support, technical manpower support, infrastructure and entrepreneurship programme etc.

Hafiz Muhammad Inamullah, et. al. (2009) (50) studied and highlighted the present profile of technical education in NWFP, Pakistan, and to pinpoint the physical facilities problems of technical education and also to highlight the academic problems in technical education, and to recommend strategies for the improvement of technical education in Pakistan. Their research showed that the facilities of laboratory and computer are sufficient, while building, transport, first aid, hostel, fire fighting facilities, latest reading material, on line research facilities, and budget, are not sufficient in the institutions of technical education. It is revealed that the overall physical facilities were not satisfactory. Similarly, the teachers were academically sound but not abreast with modern teaching techniques, nor are a budget allocated for their training. There were no guidance and counseling services in the system. Technical education has been one of the most important fields of concern for past decades. The research in this field started in early fifties and it is still going on. The literature is replete with various works bordering on university admission, student performance, and related problem.

In 1975, Bakare (51) summarized the factors and variables affecting student's performance into the intellective and non-intellective factors, emphasizing that the intellectual abilities were the best measure (Bakare 1975). He categorized causes of poor academic performance into four major classes:

1) Causes resident in society
2) Causes resident in school
3) Causes resident in the family
4) Causes resident in the student.

Studies such as (Lage and Tregelia, 1996) (52) and (Dynan, 1977 (53)) looked at a more general aspects of success while Anderson et al., 1994 (54) studied the effect of factors such as gender, student age, and students' high school scores in mathematics, English, and economics, on the level of university attainment. According to their study, students who received better scores in high school also performed better in university. Another aspect discovered was that men had better grades than women and choose to drop from school less often.

Mamun M.Z. (2000) (55) analyzed a number of non-govt. universities and found out that Human Resource Development and Management**,** and Customer Focus and Satisfaction are factors which were leading to weak performance of the universities. He saw that they were doing moderate in the areas of Quality and Operational Results, Leadership, Information and Analysis. In the areas of Management of Process Quality, and Strategic Quality Planning the performance is a little better. Hence the universities can focus more on its human resources (e.g., faculty and staff development), highlighting customer needs (e.g., quality education, better library facility, laboratory facilities, internship assistance, etc.). Strong leadership is also found paramount important inefficient running of the universities. He applied TQM and found out various areas in which the universities are weak and gave an exact result and also suggested the areas to be taken care of for better performance.

2.5 Techniques Employed for Quality Control

Quality control in technical or higher education is a major issue from past decades. Research has been going on in this field for years and different types of techniques have been employed by the researchers in order to achieve desired results.

Some of the techniques used are: Total Quality Management (TQM) (4),Quality Function Deployment (QFD) (28), Statistical Process Control (SPC) (40), ISO 9001:2000 (36:21), Business Process Re-engineering (BPR) (33), Data Envelopment Analysis (DEA) (25), EFQM Excellence Model (26), Deming's cycle and its 14 points (20), Force Field Analysis (28), Analytical Hierarchy Process (AHP) (44) and Geometry Mean Process (GM) etc.

The above techniques are used very effectively and have also proven to give good results and hence helped various institutions to control the quality of technical education all over the world.

2.6 Summary of review and gaps identified

The chapter gives us the brief knowledge about the work done to control the quality of technical education over the years. It also shows the developments and the need of the research. We can see the importance of the education sector and various models proposed to monitor the quality of technical education. Various scientists have done research in the field of technical education. Various techniques have been employed for this purpose but no technique is found to be very accurate. Techniques like ANN, Fuzzy logic, SPC, Fuzzy AHP and ISM have not been used in quality management in technical education. Hence there is need to apply these techniques and find out how these can be used for improving the quality in technical education and to evaluate their potential for quality management in technical education.

2.7 Objectives of the Research

The present study attempts to adopt holistic approach for analyzing various soft computing and other techniques to improve the quality in Technical Education. On the basis of literature review and gaps identified this research is aimed to achieve the following objectives.

(i). To assess the potential/ accuracy of ANN to improve the quality in technical education with regards to academic results.

(ii). To develop Fuzzy logic Models for predicting placement of the students and assessing the factors affecting the quality in Technical Education.

(iii). Systematic integrated approach for modeling various attributes affecting the quality in Technical Education System (TES).

(iv) To determine the rank of the attributes capable of affecting quality of a TES using Fuzzy AHP and to test the adequacy of Fuzzy AHP for modeling the Attributes of quality in education.

(v). To develop a hierarchy of various factors to improve the quality in Technical Education System (TES) using interpretive structural modeling (ISM).

(vi). Ranking and comparative study of Engineering colleges using SPC, statistical method/ Survey analysis etc to improve the quality in Technical Education.

Chapter 3

Research Methodology

3.1 Introduction

Quality control in technical or higher education is a major issue from past decades. Research has been going on in the field of service industries for years and different types of techniques or methods have been employed by the researchers in order to achieve desired results. However, so far very little research work seems to have been done to improve the quality in technical education.

Some of the techniques used are:

- Artificial Neural network (35),(116),(120)
- Fuzzy logic (41),(112),
- Analytical Hierarchy Process (AHP) (44)
- Statistical Process Control (SPC) (117)
- Interpretive Structural Modeling (ISM)

The above techniques are used very effectively and have also proven to give good results. In this work we have used various methods for improving and analyzing the quality of technical education. The techniques have been discussed below.

3.2 Artificial Neural Network

Inspired by the structure of the brain, a neural network consists of a set of highly interconnected entities, called Processing Elements (PE) or units. Each unit is designed to mimic its biological counterpart, the neuron. Each accepts a weighted set of inputs and responds with an output. Neural networks address problems that are often difficult for traditional computers to solve, such as speech and pattern recognition, weather forecasts, sales forecasts, scheduling of buses, power loading forecasts, early cancer detection, etc. A neural network is a more general method of regression analysis. Some of the advantages of the network over conventional regression include the following:

1) There is no need to specify a function to which the data are to be fitted. The function is an outcome of the process of creating a network.

2) The network is able to capture almost arbitrarily nonlinear relationships.

3) With Bayesian methods, it is possible to estimate the uncertainty of extrapolation.

Evaluation of service quality is attained by implementing a neural network approach (Hoefer and Gould, 2000; Tam and Kiang, 1992; Nordmann and Luxhoj, 2000). Such an approach may enable one to address three fundamental issues: first, the consideration of applying a neural network adequately for modeling of customer evaluation of service quality in education; second, since the neural network is considered to be a '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; third, the study demonstrates effective utilization of neural network models by the service providers for identification and improvement of the quality of service.

3.3 Fuzzy Logic

Logic started as the study of language in arguments and persuasion, and it may be used to judge the correctness of a chain of reasoning, in a mathematical proof for example. In two valued logic a proposition is either true or false, but not both. The ''truth'' or ''falsity'' which is assigned to a statement is its truth value. In fuzzy logic a proposition may be true or false or have an intermediate truth-value, such as may be true. The sentence the level is high is an example of such a proposition in a fuzzy controller. It may be convenient to restrict the possible truth values to a discrete domain, say (0, .5, and 1) for false, may be true and true in that case we are dealing with multi valued logic. In practice a finer subdivision of the unit interval may be more appropriate.

New product (read courses) development (NPD) is closely linked to an institute's competitiveness. Managing NPD is complex and requires consideration of customer (read student) requirements, technical issues, and competing courses and curriculums. The more closely the course fits the students' expectations, the greater the likelihood of successful course and curriculum development. Quality function deployment (QFD) is a well-known tool for identifying customer needs and translating customer requirements into a technical response. QFD translates customer requirements into technical specifications appropriate for each stage of product development and production. QFD considers customer requirements by examining development space as well as product differentiation, position, and characteristics. Moreover, QFD can enable businesses to integrate R&D, manufacturing, and management when drafting a marketing policy. QFD is based on the construction and analysis by the house of quality (HOQ), which documents the transformation of customer needs into technical specifications.

The competitive evaluation of HOQ ranks each customer requirement to combine the data of each competing product. Corporations can then employ the combined data for product differentiation and positioning. Importance ratings represent the relative importance of each customer requirement, although assigning ratings to customer requirements is sometimes made difficult by issues of objectivity and significance. Previous investigations have ranked the importance of customer requirements by focus group opinion, expert opinion, and analytical hierarchy process (AHP) analysis. Nevertheless, ranking techniques used in the past may be subjective, complex, controversial, and time-consuming. This study integrates fuzzy logic to rank each customer requirement item and calculate evaluating data in order to analyze product features and conduct product positioning more simply, accurately, objectively, and scientifically.

3.4 Analytic hierarchy process (AHP)

The AHP was developed in the 1970s by Saaty of the Wharton School of Business (Saaty, 1977, 1980) (56). It is a systematic and scientific MCDM method and is able to solve complicated and subjective decision making problems. AHP can be used to solve problems under uncertain circumstances with multiple criteria. In AHP, multiple paired comparisons are based on a standardized evaluation scheme (1=equal importance; 3=weak importance; 5=strong importance; 7=demonstrated importance; 9=absolute importance). The AHP uses pairwise comparisons to compare n elements under given conditions and then converts vague verbal response into a 9-point linguistic scale. The results of the pairwise comparisons can be used to construct a judgment matrix, and then the normalized Eigenvector corresponding to the maximum Eigen value (l max) can be calculated. The consistency of the matrix can be determined by checking the consistency ratio (CR). A CR that is less than 0.1 indicates a consistent judgment (Saaty, 1980).

3.4.1 Fuzzy AHP

Many fuzzy AHP methods have been proposed by various authors. These methods are systematic and useful approaches to the alternative selection and gives justification to the problem by using the concepts of fuzzy set theory and hierarchical structure analysis. Decision makers have experienced that it is more confident and easy to give interval judgments than fixed value judgments. This is due to the fuzzy nature of the comparison process. The Fuzzy-AHP methodology extends Saaty’s AHP by combining it with the fuzzy set theory. In the Fuzzy-AHP, fuzzy ratio scales are used to indicate the relative strength of the factors in the corresponding criteria. Therefore, a fuzzy judgment matrix can be constructed. The final scores of alternatives are also represented by fuzzy numbers. The optimum alternative is obtained by ranking the fuzzy numbers using special algebra operators. The next three steps can summarize the procedure of applying Fuzzy-AHP:

(i) Construct a hierarchical structure for the problem to be solved.

(ii) Establish the fuzzy judgment matrix and a fuzzy weight vector.

(iii) Rank all alternatives and select the optimal one.

In this methodology, all elements in the judgment matrix and weight vectors are represented by triangular fuzzy numbers. Using fuzzy numbers to indicate the relative contribution or impact of each alternative on a criterion, a fuzzy judgment vector is then obtained for each criterion. The fuzzy judgment matrix A is built with all the fuzzy judgment vectors. The weight vector W is used to represent the decision maker's opinion of the relative importance of each criterion during the decision process. A fuzzy number~x expresses the meaning 'about x'. Each membership function is defined by three parameters of the symmetric triangular fuzzy number, (l, m, r), left, middle and right points of the range over which the function is defined. Fuzzy membership function and the definition of a fuzzy number are shown in Fig. 1. When the decision-maker faces a complex and uncertain problem and expresses his/her comparison judgments as uncertain ratios, such as 'about two times more important', 'between two and four times less important', etc., the standard AHP steps, and specially, Eigen value prioritization approach, cannot be considered as straightforward procedures. Indeed, the assessment of local priorities, based on pair wise comparisons needs some prioritization method to be applied.

3.5 Statistical Process Control (SPC)

SPC stands for Statistical Process Control in which the statistical technology and methodology are applied to monitor the quality of product during manufacturing process in real time It could distinguish and pick up the abnormal deviation of quality from the normal deviation scientifically and precisely, so that a certain kind of early warning could be given when an abnormal is found in manufacturing process, and a certain measures would be taken by relevant persons, e.g. try to find the causes, try to eliminate the abnormal, and try to restore a stable process, etc. It's necessary for a enterprise to achieve the targets of quality control and improving.

Walter Shewhart, the founder of SPC, had presented some famous comments on application of SPC:

- There are 2 factors appeared in deviation for all manufacturing processes, one is a stable factor, the normal deviation, which is caused by process itself and another is an interrupted factor, the abnormal deviation, which its causes could be found out.
- The abnormal deviation can be found out and eliminated by some effective methods, but the normal deviation will never be disappeared unless the basic manufacturing process is altered.
- The 3σ SPC control charts could be used to distinguish the abnormal deviation from normal deviation.

SPC is not only a tool for identifying trends or changes, but also provides relevant information whether a process is in control or not. The data obtained from questionnaire are plotted about the mean, range, or proportion. Using the appropriate control chart, one can make diagnosis about the process. If a sample exceeds a control limit, there is strong possibility that an assignable cause exists for this variation, such as major differences attributed to the implementation of a new initiative. If a sample does not exceed a limit, then sample-to-sample variation may just be due to common cause variation. By allowing variations to be examined in a logical manner, control charts can provide engineering educators with the information needed to make a systematic change. SPC has been widely used in quality management for enterprises and it has proved effective to monitor production process. To promote the teaching quality is one of the main objectives for colleges and universities in current period. Teaching means process.

3.6 Interpretive Structural Modeling (ISM)

ISM i.e. Interpretive Structural Modeling is an interactive learning process. The method is interpretive in that the group's judgment decides whether and how items are related, it is structural in that, on the basis of the relationship, an overall structure is extracted from the complex set of items, and it is modeling in that the specific relationships and overall structure are portrayed in a diagraph model. ISM methodology helps to impose order and direction of relationships among elements of a system (Sage, 1977). It provides us a means by which order can be imposed on the complexity of such variables (Mandal and Deshmukh, 1994; Jharkharia and Shankar, 2005). However, the direct and indirect relationships between the factors describe the situation far more accurately than the individual factor taken in isolation. Therefore, ISM develops insights into collective understandings of these relationships. The application of ISM helps to reassess perceived priorities and improve their understanding of the linkages among key concerns.

3.7 Conclusions

The chapter gives a brief details about the techniques used in the research work. All these techniques viz Artificial Neural Network , Fuzzy logic, Fuzzy AHP, Statistical Process Control (SPC), Interpretive Structural Modeling (ISM) seem to be highly useful for improving the academic results, assessing the factors and their importance to improve the quality of the institution, prediction of the placement of the students, possible causes for the poor performance of the students, ranking of the various variables to improve the level of technical education, ranking of engg. colleges etc. and have been used successfully the research work.

Chapter 4

Application of various techniques of Quality Management in Technical Education

4.1 Case study No. 1-Application of ANN for Quality Management in Technical Education*

4.1.1 Introduction

The main difference between human & machine intelligence comes from the fact that humans perceive everything as pattern, whereas for a machine everything is data (Greenberger, 1962). Even in routine data consisting of integer numbers (like telephone numbers, bank account numbers, car numbers) humans tends to perceive a pattern. The pattern nature in storage and recall automatically gives robustness and fault tolerance for the human system. Human beings and machines differ in the sense that human beings understand patterns whereas machine can be said to recognize the patterns in data.

Inspired by the structure of the brain, a neural network consists of a set of highly interconnected entities, called Processing Elements (PE) or units. Each unit is designed to mimic its biological counterpart, the neuron. Each accepts a weighted set of inputs and responds with an output. Neural networks address problems that are often difficult for traditional computers to solve, such as speech and pattern recognition, weather forecasts, sales forecasts, scheduling of buses, power loading forecasts, early cancer detection, etc. A neural network is a more general method of regression analysis. With the help of regression analysis, we can predict the unknown values of one variable from known values of another variable. The regression equation of Y on X is expressed as. $Y = a + bX$

Some of the advantages of the network over conventional regression include the following:

1) There is no need to specify a function to which the data are to be fitted. The function is an outcome of the process of creating a network.
2) The network is able to capture almost arbitrarily nonlinear relationships.
3) With Bayesian methods, it is possible to estimate the uncertainty of extrapolation.

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4.1.2 PERFORMANCE COMPARISON OF COMPUTER AND BIOLOGICAL NEURAL NETWORKS

Since ANN is implemented on computers, it is worth comparing the processing capabilities of a computer with those of the brain (SIMPSON1990):

Speed: Neural networks are slow in processing information. The processing time execution of information using advance computers is of few nanoseconds while with neural network this ranges in few milliseconds. Thus computer processes information nearly a million times faster.

Processing: Neural networks can perform many parallel operations. Most programmes have large number of instructions and they operate in a sequential mode one instruction after another on conventional computer. On the other hand brain operates with many parallel operations, each of them having fewer steps. This explains the superior performance of human information processing for certain task.

Size and Complexity: Neural network have large number of computing elements and the computing is not restricted to within neurons. The number of neurons in a brain is estimated to be about $10^{11}$and total number of interconnections to be around 10^{15}. It is this size and complexity of connections that may be giving the brain the power of performing complex pattern recognition tasks which are unable to realize on a computer.

Storage: Neural networks store information in the strengths of the interconnection. In computer information is stored in the memory which is addressed by its location. Any new information on same location destroys the old information. In contrast, in a neural network new information is added by adjusting the interconnection strength, without destroying the old information. Thus information in brain is adaptable whereas in the computer it is replaceable.

Fault Tolerance: Neural network exhibit fault tolerance since the information is distributed in the connections throughout the network. Even if a few connections are snapped or a few neurons are not functioning, the information is still preserved due to the distributed nature of the encoded information. In computers there is no fault tolerance i.e. if information corrupted in the memory cannot be retrieved.

Control Mechanism: There is no central control for processing information in the brain. In a computer there is a control unit which monitors all the activities of computing. In neural network each neuron works on the information locally available and transmits its output to the neuron connected to it. Thus there is no specific mechanism external to the computing task. The complexity and flexibility of the relationship that can be created is thus tremendous. Another desirable feature of network models is that they are readily updated as more historical data becomes available; that is, the models continue to learn and extend their knowledge base. Thus artificial neural network model are referred to as adaptive systems. This similarity to the human brain enables the neural network to simulate a wide range of functional forms which are either linear or non-linear. They also provide some insight into the way the human brain works. One of the most significant strengths of neural networks is their ability to learn from a limited set of examples. Generally a neural network consists of **n** layers of neurons of which two are input and output layers, respectively. The former is the first and the only layer which receives and transmits external signals while the latter is the last and the one that sends out the results of the computations. The n-2 inner ones are called hidden layers which extract, in relays, relevant features or patterns from received signals. Those features considered important are then directed to the output layer. Sophisticated neural networks may have several hidden layers, feedback loops, and time-delay elements, which are designed to make the network as effective as possible in discriminating relevant features or patterns. The ability of an ANN to handle complex problems depends on the number of the hidden layers although recent studies suggest three hidden layers as being adequate for most complex problems. There are feed-forward, back-propagation, and feedback types of networks depending on the manner of neuron connections. The first allows only neuron connections between two different layers. The second has not only feed-forward but also 'error feedback' connections from each of the neurons above it. The last shares the same features as the first, but with feedback connections, that permit more training or learning iterations before results can be generated. ANN learning can be either supervised or unsupervised. In supervised learning, the network is first trained using a set of actual data referred to as the training set. The actual outputs for each input signal are made available to the network during the training. Processing of the input and result comparison is then done by the network to get errors which are then back propagated, causing the system to adjust the weights which control the network. In unsupervised learning, only the inputs are provided, without any outputs: the results of the learning process cannot be determined. This training is considered complete when the neural network reaches a user defined performance level. Such networks internally monitor their performance by looking for regularities or trends in the input signals, and make adaptations according to the function of the network. This information is built into the network topology and learning rules. Typically, the weights are frozen for the application even though some network types allow continual training at a much slower rate while in operation. This helps a network to adapt gradually to changing conditions. For this work, supervised training is used because it gives faster learning than the unsupervised training.

In supervised training, the data is divided into 3 categories: the training, verification, and testing sets. The Training Set allows the system to observe the type of relationships between input data and outputs. In the process, it develops a relationship between them. A heuristic state that the number of the training set data should be at least a factor of 10 times the number of network weights to adequately classify test data. About 60% of the total sample data was used for network training in this work. The Verification Set is used to check the degree of learning of the network in order to determine if the network is converging correctly for adequate generalization ability. Ten percent of the total sample data was used in this study. The Test/Validation Set is used to evaluate the performance of the neural network. About 30% of the total sample data served as test data.

4.1.3 The Input Variables

The input variables selected are those which can easily be obtained from students' application/ record cards in the student's department.

The input variables are:

1) Entrance Exam score/Rank,
2) Intermediate exam results in Mathematics, English Language, Physics, and Chemistry,
3) Further mathematics,
4) Age of student at admission,
5) Time that has elapsed between graduating from secondary school and gaining university admission,
6) Parents educational status,
7) Zonal location of student's secondary school,
8) Type of secondary school attended (privately owned, State or Central government owned),
9) Location of university and place of residence, and
10) Student's Gender.

These factors were transformed into a format suitable for neural network analysis. The domain of the input variables used in this study shown in Table 4.1.

Table 4.1 Input Data Transformation

S/N	Input variable	Domain		
1	CEE score	Score	Normalized score	
2	Intermediate results	Maths	First	1
			Second	2
			Third	3
		English	First	1
			Second	2
			Third	3
		Physics	First	1
			Second	2
			Third	3

		Chemistry	First Second Third	1 2 3
3	High-school math	First Second Third		1 2 3
4	Age at entry	Below 23 years 23 years-above		1 2
5	Time before admission	1 year 2year 3years- above		1 2 3
6	Educated parent(s)	Yes No		1 2
7	Zone of secondary school attended	West South East North Centre		1 2 3 4 5
8	Type of secondary school	Private State Central		1 2 3
9	Location of school	Located in home state Outside home state		1 2
10	Gender	Male Female		1 2

(* Since the general University Matriculation Examination performance may vary yearly normalizing is necessary. The normalized score = (candidate score)/ (average score for the class)

4.1.4 The Output Variable

The output variable represents the performance of a student on graduation. The output variable is based on the current grading system used by the university. However, for the scope of this project, the domain of the output variables represents some range of Cumulative Grade Point Averages (CGPA).

Table 4.2 Output Data Transformation

S/N	Output variable	Domain	
		Class	**CGPA**
1	GOOD	1^{st} class 2^{nd} class Upper	 6.0-7.0 4.6-5.9
2	AVERAGE	2^{nd} class Lower	 2.4-4.5
3	POOR	3^{rd} class Pass	1.8-2.3 1.0-1.7

The classification of output variable domain chosen above, that is 1st class and 2nd class upper as 'GOOD', 2nd class lower as 'AVERAGE', and 3rd class and pass as 'POOR', follows the practice of classifying candidates into these domains by most employing companies and postgraduate institutions, using the order stated above.

4.1.5 Multilayer Perceptions

Multilayer Perceptions (MLPs) are layered feed forward networks typically trained with static back propagation. These networks have found their way into countless applications requiring static pattern classification. Their main advantage is that they are easy to use, and that they can approximate any input/output map. The key disadvantages are that they train slowly and require lots of training data.

4.1.6 The Network Layers and Processing Elements

The next step in building the neural network model is the determination of the number of processing elements and hidden layers in the network. Selection of the number of processing elements and hidden layers is a delicate one because having a small number of hidden layers in a neural network lowers the processing capability of the network. Similarly, a large number of hidden layers will progressively slow down the training time. In determining the number of hidden layers to be used, there are two methods in the selection of network sizes: one can begin with a small network and then increase its size (i.e. Growing Method); the other method is to begin with a complex network and then reduce its size by removing not so important components (i.e. Pruning Method) (Hertz, 1991) (57). The Growing Method was used in the building of the neural network model. Hence, the experimentation involves starting with no hidden layers and then gradually increasing them.

Trade-offs has to be made in determining the number of processing elements (PE). This is because, a large number of PE's can give the network a possibility of fitting very complex discriminate functions, and also involves a large number of weights. It has been shown that having too many weights can lead to poor generalization (Adefowoju and Osofisan, 2004) (58). On the other hand, having too few PE's reduces the discriminating power of the network. Since it is not possible to set the number of PE's analytically, the number of PE's is also varied in the study from 1 to 5 nodes, to arrive at the best performance network. The experiment is thus started with a small number of PE's, and observations made on the behavior of the learning curve. If the final training error is of a small and acceptable value, then the network has the right number of PE's. However, if the final error is large, then one of two things has happened: either the learning curve has found itself in a local minimum or the network lacks enough capability to get the problem solved, so the number of PE's should be increased.

4.1.7 The Data Set Grouping

In supervised training, the data is divided into 3 categories; the training set, verification set and the testing set. The training set enables the system to observe relationships between input data and resulting outputs, so that it can develop relationship between the input and the expected output.

A heuristic state that the number of the training set data should be at least a factor of 10 larger than the number of network weight to accurately classify test data with 90% accuracy. A total of 119 students records were used in the analysis. About 56% of the total data (i.e. 65 candidates) were used as the training set, 30% (i.e. 36 candidates) as the testing set, and 14% (i.e. 17 candidates) used for cross validation.

4.1.8 Neural Network Topology

After the data classification, the neural network topology was built based on the Multilayer Perception with two hidden layers and five processing elements per layer.

4.1.8.1 Network Training and Validation Process

The network was trained with the number of runs set to three and the Epoch set to terminate at 1000. The training performance is then evaluated using the following performance measures:

- The Mean Square Error (MSE)

$$MSE = \frac{\sum_{\substack{0 \leq i \leq N \\ 0 < j < P}} (d_{ij} - Y_{ij})^2}{NP}$$

Where:
p = number of output of processing element.
N= No. of exemplars in the data set.
Y_{ij}= network output for exemplars i at processing element j,
d_{ij}= desired output for exemplars i at processing element j,

4.1.8.2 Network Testing

After the training and cross Validation, the network was tested with the Test data set and the following results were obtained. This involves given the input variable data to the network without the output variable results. The output from the network is then compared with the actual variable data. The comparison is summarized in the matrix bellow.

Table 4.3 Results from Testing

Output/Desired	Good	Average	Poor
Good	9	3	1
Average	2	8	0
Poor	0	4	7

The network was able to predict accurately 9 out of 11 for the good data (which represents candidates with either a 1st Class or 2nd Class upper), 8 out of 15 of the Average data (which represents candidates with a 2nd Class lower) and 7 out of 8 of the Poor data (which represents candidates with a 3rd Class or Pass) used to test the Network's topology. This gives an accuracy of 82% for Good, 53% for Average and 88% for the Poor classification. This indicates an accuracy of about 74% for the Artificial Neural network's which is a fair performance going by similar results from the literature.

4.1.9 Conclusion and Recommendations

This study has shown the potential of the artificial neural network for enhancing the effectiveness of a university admission system. The model was developed based on some selected input variables from the pre admission data of five different sets of university graduates. It achieved an accuracy of over 73%, which shows the potential efficacy of Artificial Neural Network as a prediction tool and a selection criterion for candidates seeking admission into a university. One limitation of this model stems from the fact that not all the relevant performance influencing factors are obtainable from the pre-admission record forms filled by the students. A model incorporating the use of results from a carefully designed oral interview administered to the students may likely be an improvement over the present model. Also the extension this research to non-engineering departments is recommended.

The current admissions system should be reviewed in order to improve the standard of candidates being admitted into the institution. A more adequate ANN may be very useful for such an exercise.

4.2 <u>Application of Fuzzy Logic for Quality Management in Technical Education</u>

4.2.1 Introduction

Fuzzy logic is all about the relative importance of precision: How important is it to be exactly right when a rough answer will do? All books on fuzzy logic begin with a few good quotes on this very topic, and this is no exception. Here is what some clever people have said in the past.

- Precision is not truth. — Henri Matisse
- Sometimes the more measurable drives out the most important. — René Dubos
- Vagueness is no more to be done away with in the world of logic than friction in mechanics. — Charles Sanders Peirce
- Examples of Fuzzy Logic :
    - The description of a human characteristic such as healthy;
    - The classification of patients as depressed;
    - The classification of certain objects as large;
    - The classification of people by age such as old;
    - A rule for driving such as “if an obstacle is close, then brake immediately”.

In above examples, terms such as depressed and old are fuzzy in the sense as they are not sharply defined. However this fuzzy information’s are used by us for decision making.

Is a person depressed or not?

Is the quality control of specific technical institution is of acceptable degree or not?
In case we look for an answer yes or no, it is possible and is usually done but there may be a loss of information in doing so because no account is taken of the degree of depression and degree of quality of TES. In this time of rapidly advancing technology, the dream of producing machine that mimic human reasoning which is based on uncertain and imprecise information has captured the attention of many scientist and engineers. With the success of automatic control and of expert systems we can now witness of endorsement of fuzzy concepts in quality management in TES.

4.2.2 Literature Review

In 1992, Daniel Z. Sui proposed a fuzzy GIS (geographical information system) modeling approach for urban land evaluation. His research demonstrates the usefulness of Zadeh's fuzzy set theory in GIS modeling for urban land evaluation. The results indicate that incorporating fuzzy set theory into GIS modeling can provide more & tells about the gradual transition of urban land value than the traditional cartographic modeling approach. Fuzzy GIS modeling can also reduce the information loss by obtaining membership grade for each individual land parcel. The membership function allows identification of the extent to which a particular area belongs to a valuation class based on given criteria.
Arvind Verma (1997), applied fuzzy logic for construction of offender profiles. He proposed a fuzzy logic based mathematical procedure for criminal's justice fields. He found out that this is a strong mathematical technique that can handle imprecise and fuzzy data is undoubtedly going to strengthen the analytical capabilities of the social researchers. Above all, an exposure to the concept of fuzzy variables and an understanding of the mathematical base of fuzzy logic could initiate a new research process for police and criminal justice fields, for obviously this is only a beginning.
In 2003, Barry Shore and A.R. Venkatachalam, used fuzzy logic technique for evaluation of the information sharing capabilities of supply chain partners. The methodology allows decision makers to evaluate information sharing capability of suppliers in a natural way while preserving the fuzziness of the measurement process and capturing data in linguistic terms. Fuzzy logic, used extensively in engineering for control problems, seems potentially very useful in solving a range of supply chain evaluation problems. While the purpose of this paper is to introduce the methodology, the next step should be to apply this methodology to an actual problem and extend the methodology to a wider range of evaluation problems.
In 2004, Shyi-Ming Chena and Chia-Ching Hsub presented a new method for forecasting the enrollments of the University of Alabama using fuzzy time series. The proposed method belongs to the first order and time-variant methods. The proposed method gets a

higher forecasting accuracy rate for forecasting enrollments than the existing methods. S.A. Oke in 2006 used fuzzy logic control model for Gantt charting preventive maintenance scheduling. The research has serious implication in terms of the ability to monitor the Imprecision those were introduced in early work. He provides a more reliable framework for researchers and practitioners interested in maintenance scheduling activities. In 2007, Stefano Malagoli and Carlo Alberto Magni used fuzzy logic and expert systems to provide a score for the firm(s) under consideration, representing the firm value-creating power. They introduced a system which was capable of dealing with both quantitative and qualitative variables and integrates financial, managerial and strategic variables. The use of a fuzzy expert system for ranking firms within a sector and pricing firms is a first attempt at an alternative way of measuring performance and value. Later in the year 2008, Hooshang M. Beheshti described the development of fuzzy logic model approach to decision making and its value for managers by illustration its application to employee performance and appraisal. The research gave an alternative method of the performance evaluation system as opposed to the traditional quantitative method. Sharon M. Ordoobadi in 2008, proposed a tool for decision makers to make more informed decisions regarding their investment in advanced technologies. He proposed that addition of subjective perceptions to the purely quantitative approach provides a more realistic evaluation process. He founded a procedure that would help practitioners with their technology. The value of the paper is the inclusion of the decision maker's judgment in the evaluation process by use of fuzzy logic. Maria J. Munoz and Juana M. Rivera (2008) used fuzzy logic for evaluating sustainability in organizations. His aim was to determine whether the organizations more strategically committed to their stakeholders present better social and financial performance and, based on this relationship, to determine the state of the art of the Spanish sectors' approach to sustainable development.

4.2.3 Fuzzy Set Theory

Fuzzy set theory introduced by Zadeh (1965) (59) is used to represent the vagueness of human thinking; it expands traditional logic to include instances of partial truth. In traditional set theory, elements have either complete membership or complete non-membership in a given set. With fuzzy set theory, intermediate degrees of membership are allowed. The coding of the degree of membership to each of the elements in the set is defined as the membership function of the fuzzy set. The membership function is commonly depicted as a membership curve. The membership curve contains three main components: the horizontal axis consisting of domain elements (usually real numbers) of the fuzzy set, the vertical axis consisting of the degree of membership scale from 0 to1, and the surface of the set itself which relates the degree of membership to the domain element. These membership curves can take on several shapes, but the triangular and trapezoidal are the most frequently used. This type of methodology is very useful when the model requires human perceptions as inputs where ambiguity and vagueness exists. In particular, systems requiring linguistic descriptions are more easily modeled using fuzzy sets. There are two main inputs to the evaluation process of data. The first is the decision maker's perception regarding the importance weight of the criteria of interest. The second input is how the decision-maker rates each parameter with respect to objective. However, it is very difficult to obtain exact assessments from the decision maker. Subjectivity of human assessments and beliefs can be expressed by using linguistic terms such as "low importance" or "highly likely." The fuzzy set theory and fuzzy numbers allow such qualitative expressions. As a result, their use in modeling of our proposed system seems a logical choice.

4.2.4 Fuzzy membership functions

Here, the decision maker's perception is solicited in area: importance of each factor, and the performance of each factor. Thus, we define the trapezoidal fuzzy membership functions: for assessment.

The Fuzzy Logic includes various membership functions. These functions are, built from several basic functions: piecewise linear functions, the Gaussian distribution function etc. By convention, all membership functions have the letters **mf** at the end of their names.

- The simplest is the triangular membership function, and it has the function name trimf. It is nothing more than a collection of three points forming a triangle.
- The trapezoidal membership function, trapmf, has a flat top and really is just a truncated triangle curve. These straight line membership functions have the advantage of simplicity.
- One membership functions are built on the Gaussian distribution curve: a simple Gaussian curve name as gaussmf.

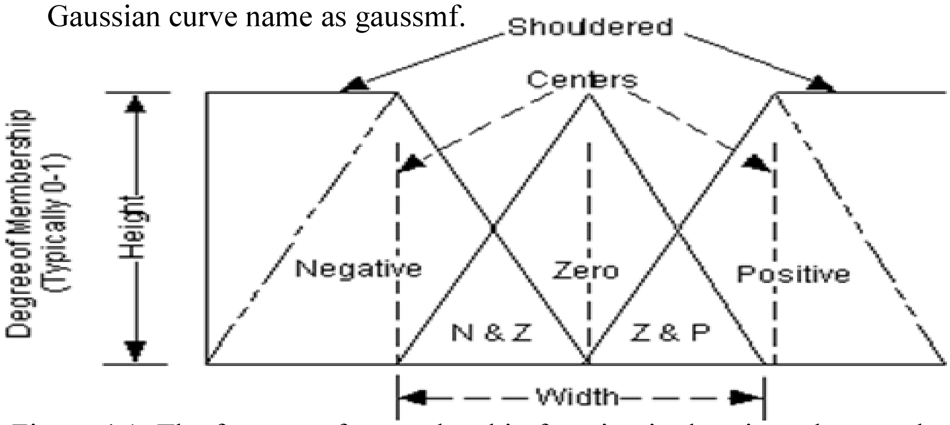

Figure 4.1: The features of a membership function in the triangular membership.

The generalized bell membership function is specified by three parameters and has the function name gbellmf. Because of their smoothness and concise notation, Gaussian and bell membership functions are popular methods for specifying fuzzy sets. Both of these curves have the advantage of being smooth and nonzero at all points.

4.2.5 Fuzzy Rule

The "smartness" of fuzzy is dependent on the rules given. The greater the number of rules, the "smarter" the machine gets. However, this means that the performance of the fuzzy machines is restricted by the capabilities of the human brain. Therefore, how do we make the machines think for themselves and come up with rules of its own? In most fuzzy problem the rules are generated based on past experience. When any problem deals with fuzzy control one should know all possible input/output relationships in fuzzy term. So that rules can be expressed in term of IF-THEN statements. Linguistic rules describing the control system consist of two parts; an antecedent block (between the IF and THEN) and a consequent block (following THEN). Depending on the system, it may not be necessary to evaluate every possible input combination since some may rarely or never occur. By making this type of evaluation, usually done by an experienced operator, fewer rules can be evaluated, thus simplifying the processing logic and perhaps even improving the FL system performance.

Fuzzy logic based systems are one of the main development and successes of fuzzy sets and fuzzy logic. A fuzzy logic based system is a rule base system that implements a nonlinear mapping between inputs and outputs.

A fuzzy logic based system includes following.

1. Fuzzifier
2. Defuzzifier
3. Inference engine
4. Rule base

The operation of FLS is based on the rules contained in rule base. Fuzzy sets and fuzzy operators are the subjects and verbs of fuzzy logic. While if-then rule statements are used to formulate the conditional statements that comprise fuzzy logic. A single fuzzy if-then rule assumes the form

If x is A then y is B

Where A and B are linguistic values defined by fuzzy sets on the ranges (universes of discourse) X and Y, respectively. The if-part of the rule "x is A" is called the antecedent or premise, while the then-part of the rule "y is B" is called the consequent or conclusion. An example of such a rule might be:

If service is poor then customer strength is low.

Here poor is represented as a number between 0 and 1, and so the antecedent is an interpretation that returns a single number between 0 and 1. On the other hand, low is represented as a fuzzy set, and so the consequent is an assignment that assigns the entire fuzzy set B to the output variable y. In the if-then rule, the word "is" gets used in two entirely different ways depending on whether it appears in the antecedent or the consequent. In general, the input to an if-then rule is the current value for the input variable (in this case, service) and the output is an entire fuzzy set (in this case, low). This set will later be defuzzified, assigning one value to the output. Interpreting an if-then rule involves distinct parts: first evaluating the antecedent (which involves fuzzifying the input and applying any necessary fuzzy operators) and second applying that result to the consequent (known as implication). if the antecedent is true to some degree of membership, then the consequent is also true to that same degree. Interpreting if-then rules is a three-part process.

Fuzzify inputs: Resolve all fuzzy statements in the antecedent to a degree of membership between 0 and 1. If there is only one part to the antecedent, this is the degree of support for the rule. Apply fuzzy operator to multiple part antecedents: If there are multiple parts to the antecedent, apply fuzzy logic operators and resolve the antecedent to a single number between 0 and 1. This is the degree of support for the rule. Apply implication method: Use the degree of support for the entire rule to shape the output fuzzy set. The consequent of a fuzzy rule assigns an entire fuzzy set to the output. This fuzzy set is represented by a membership function that is chosen to indicate the qualities of the consequent. If the antecedent is only partially true, (i.e., is assigned a value less than 1), then the output fuzzy set is truncated according to the implication method.

Inference engine: The last step is to determine the firing strength of each rule. The logical products for each rule must be combined or inferred. Before being passed on to the de-fuzzification, process for crisp output generation. Several inference methods exist.

The max-min method tests the magnitudes of each rule and selects the highest one.

The max-dot or max-product method scales each member function to fit under its respective peak value and takes the horizontal coordinate of the "fuzzy" centroid of the composite area under the function(s) as the output.

Defuzzification - Getting back to crisp numbers

A defuzzification strategy is aimed at producing a no fuzzy control action that best represent the possible distribution of an inferred fuzzy control action. Unfortunately there is no systematic procedure for choosing the defuzzification strategy.

A "fuzzy centroid" algorithm

The defuzzification of the data into a crisp output is accomplished by combining the results of the inference process and then computing the "fuzzy centroid" of the area. The weighted strengths of each output member function are multiplied by their respective output membership function center points and summed. Finally, this area is divided by the sum of the weighted member function strengths and the result is taken as the crisp output.

4.2.6 Conclusions

The trapezoidal curve is a function of vector x, and depends on four scale parameters a, b, c, d is given by: The parameters a and d locate the“feet” of the trapezoidal and parameters b and c locate the “shoulders.

$$f(x,a,b,c,d) = \begin{Bmatrix} 0, x < a \\ \frac{x-a}{b-a} \quad a \le x \le b \\ 1, \quad b \le x \le c \\ \frac{d-x}{d-c}, c \le x \le d \\ 0, \quad d \le x \end{Bmatrix}$$

The importance of quality control and improvement needs an effective quality management system in the education sector which can control, monitor and improve the quality of technical education. Quality of teaching is a major focus for colleges and universities. The management and monitoring of teaching process should be enhanced. The fuzzy logic using MAT LAB technique gives us the precise information about where the problem exists and how much input is desired to improve the quality.

4.3 Case study No. 2-Prediction of quality of technical education using Fuzzy Logic*

4.3.1 Introduction

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

- Math and computation
- Algorithm development
- Data acquisition
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time. MATLAB features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, **fuzzy logic**, wavelets, simulation, and many others. MATLAB Desktop When we start MATLAB, the MATLAB desktop appears, containing tools (graphical user interfaces) for managing files, variables, and applications associated with MATLAB.

4.3.2 Research objectives

In the education sector there are large numbers of parameters that need to pay attention but their criticality is very imprecisely defined so which factor must pay attention up to what degree can determined using fuzzy technique. Hence, the need for decision making over each parameter can be judged by fuzzy logic technique.

Following objectives can be drawn up for this study:

• To develop an instrument for predicting improvement in quality of technical education.
• To determine the firing strength of various factors on quality of technical education.
• To test the adequacy of Fuzzy logic for modeling the evaluation of quality in technical education.

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4.3.3 Application

There are large numbers of parameters or factors that can be analyzed to predict the quality of technical education. Here we take around fourteen factors as per previous research and expert suggestion that includes the areas where the improvements in the service are required for a TES in the context of this study. Thus a questionnaire is prepared and sent for expert opinion. These various factors are considered as input for fuzzy sets.

4.3.4 Data Collection & Analysis

Data were collected from the experts of different technical institutions (both private and government) & Industry through various mode of communication by attaching the questionnaire comprising 14 factors on expectations as well as perceptions related to quality of Technical education. The respondents were requested to answer in a scale from1 to 10. thus from the survey carried out in the NCR zones we obtain responses of 250 experts from profession of teaching as well as industry having enough experience to give feedback on the questionnaire. After getting responses the process of giving weight age to each factor was carried out .by comparing the opinion of each expert and then find out the average or mean rating for the factors. Rating is done by evaluating the data in the form of matrix of factor and expert opinion (as shown below). This data is used as the firing strength of each rule while carrying out MATLAB fuzzy logic analysis to predict the result regarding the quality of education.

Table 4.4 Data for finding the firing strength of individual parameter

S. No. (Factor)	Parameters for Expert Opinion													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1	8	7	9	9	10	9	10	9	7	9	8	8	8	9
2	8	9	10	9	9	8	10	8	8	7	9	6	7	9
3	8	9	10	8	10	8	10	9	7	7	9	10	8	9
4	9	8	10	10	10	10	9	10	8	8	7	7	9	9
5	9	9	10	10	7	7	10	7	7	6	6	6	7	10
6	6	5	3	7	7	8	9	6	2	3	3	5	2	9

7	8	4	6	5	8	7	9	4	3	2	3	4	6	9
8	9	9	10	7	7	7	9	7	6	5	5	5	6	7
9	8	7	9	9	10	9	10	9	7	9	8	8	8	9
10	8	9	10	9	9	8	10	8	8	7	9	6	7	9
11	8	9	10	8	10	8	10	9	7	7	9	10	8	9
12	8	9	10	8	10	8	10	9	7	7	9	10	8	9
13	9	8	10	10	10	10	9	10	8	8	7	7	9	9
14	9	9	10	10	7	7	10	7	7	6	6	6	7	10
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20	9	9	10	10	7	7	10	7	7	6	6	6	7	10
21	6	5	3	7	7	8	9	6	2	3	3	5	2	9
22	8	7	9	9	10	9	10	9	7	9	8	8	8	9
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29	9	8	10	10	10	10	9	10	8	8	7	7	9	9
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31	6	5	3	7	7	8	9	6	2	3	3	5	2	9

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33	9	9	10	7	7	7	9	7	6	5	5	5	6	7
34	8	7	9	9	10	9	10	9	7	9	8	8	8	9
35	8	9	10	9	9	8	10	8	8	7	9	6	7	9
36	8	9	10	8	10	8	10	9	7	7	9	10	8	9
37	8	9	10	8	10	8	10	9	7	7	9	10	8	9
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139	9	9	10	10	7	7	10	7	7	6	6	6	7	10
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142	8	4	6	5	8	7	9	4	3	2	3	4	6	9
143	8	4	6	5	8	7	9	4	3	2	3	4	6	9
144	9	9	10	7	7	7	9	7	6	5	5	5	6	7
145	9	9	10	10	7	7	10	7	7	6	6	6	7	10
146	6	5	3	7	7	8	9	6	2	3	3	5	2	9
147	8	7	9	9	10	9	10	9	7	9	8	8	8	9
148	9	9	10	10	7	7	10	7	7	6	6	6	7	10
149	6	5	3	7	7	8	9	6	2	3	3	5	2	9
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188	9	8	10	10	10	10	9	10	8	8	7	7	9	9
189	9	9	10	10	7	7	10	7	7	6	6	6	7	10
190	9	9	10	10	7	7	10	7	7	6	6	6	7	10
191	6	5	3	7	7	8	9	6	2	3	3	5	2	9
192	8	4	6	5	8	7	9	4	3	2	3	4	6	9
193	8	4	6	5	8	7	9	4	3	2	3	4	6	9
194	9	9	10	7	7	7	9	7	6	5	5	5	6	7
195	9	9	10	10	7	7	10	7	7	6	6	6	7	10
196	6	5	3	7	7	8	9	6	2	3	3	5	2	9
197	8	7	9	9	10	9	10	9	7	9	8	8	8	9
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202	8	9	10	9	9	8	10	8	8	7	9	6	7	9
203	8	9	10	8	10	8	10	9	7	7	9	10	8	9
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205	9	9	10	10	7	7	10	7	7	6	6	6	7	10
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208	9	9	10	7	7	7	9	7	6	5	5	5	6	7
209	8	7	9	9	10	9	10	9	7	9	8	8	8	9
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213	9	8	10	10	10	10	9	10	8	8	7	7	9	9

214	9	9	10	10	7	7	10	7	7	6	6	6	7	10
215	9	9	10	10	7	7	10	7	7	6	6	6	7	10
216	6	5	3	7	7	8	9	6	2	3	3	5	2	9
217	8	4	6	5	8	7	9	4	3	2	3	4	6	9
218	8	4	6	5	8	7	9	4	3	2	3	4	6	9
219	9	9	10	7	7	7	9	7	6	5	5	5	6	7
220	9	9	10	10	7	7	10	7	7	6	6	6	7	10
221	6	5	3	7	7	8	9	6	2	3	3	5	2	9
222	8	7	9	9	10	9	10	9	7	9	8	8	8	9
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224	6	5	3	7	7	8	9	6	2	3	3	5	2	9
225	8	4	6	5	8	7	9	4	3	2	3	4	6	9
226	8	7	9	9	10	9	10	9	7	9	8	8	8	9
227	8	9	10	9	9	8	10	8	8	7	9	6	7	9
228	8	9	10	8	10	8	10	9	7	7	9	10	8	9
229	9	8	10	10	10	10	9	10	8	8	7	7	9	9
230	9	9	10	10	7	7	10	7	7	6	6	6	7	10
231	6	5	3	7	7	8	9	6	2	3	3	5	2	9
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238	9	8	10	10	10	10	9	10	8	8	7	7	9	9
239	9	9	10	10	7	7	10	7	7	6	6	6	7	10

240	9	9	10	10	7	7	10	7	7	6	6	6	7	10
241	6	5	3	7	7	8	9	6	2	3	3	5	2	9
242	8	4	6	5	8	7	9	4	3	2	3	4	6	9
243	8	4	6	5	8	7	9	4	3	2	3	4	6	9
244	9	9	10	7	7	7	9	7	6	5	5	5	6	7
245	9	9	10	10	7	7	10	7	7	6	6	6	7	10
246	6	5	3	7	7	8	9	6	2	3	3	5	2	9
247	8	7	9	9	10	9	10	9	7	9	8	8	8	9
248	9	9	10	10	7	7	10	7	7	6	6	6	7	10
249	6	5	3	7	7	8	9	6	2	3	3	5	2	9
250	8	4	6	5	8	7	9	4	3	2	3	4	6	9
Sum	2010	1810	2030	2010	2070	1960	2380	1790	1410	1380	1470	1560	1590	2260
Mean	0.80	0.72	0.81	0.80	.83	0.78	.95	.72	.56	.55	.59	.62	.64	.90

Matrix for rating the expert opinion is prepared as under:

. Sr. No. in columns represents factors that are to be analyzed

. Sr. No. in rows represents the identification of expert.

. Rating is done for 0 to 10

From the above analysis of expert opinion effect of various factors is concluded after getting mean value of opinion for individual factor. So from expert point of view impact of individual factor that determines the firing strength of individual rule while applying fuzzy technique is shown below. For further analysis on those factor are consider have mean value above or equal to 0.58. It has been shown in the table 4.5 below:

Table 4.5 Ranking as per firing strength

S. No.	FACTORS	Mean	Rank
1.	Training on state-of-the-art technology	0.80	5
2.	Comprehensive learning resources	0.72	7
3.	Opportunities for campus training & placement	0.81	4
4.	Close supervision of students' work	0.80	5
5.	Expertise in subjects and well-organized lectures	0.83	3
6.	Good communication skill of academic staff	0.78	6
7.	Well-equipped laboratories with modern facilities	0.95	1
8.	Design of course structure based on job requirements	0.72	8
9.	Encouragement for sports, games and cultural activities	0.56	12
10.	Cleanliness, orderliness, systematic and methodical	0.55	13
11.	Available regularly for students' consultation	0.59	11
12.	Effective classroom management	0.62	10
13.	Recognition of the students	0.64	9
14.	Adaptability to modern techniques	0.90	2

4.3.5 Assessing importance of factor

The importance weight of a factor has three membership functions in its universe, or domain of possible values: “low” “medium” “high”. Each is modeled into (trapmf) membership shapes, the most common shape used.   For each membership function, the average value is the point at which the degree of membership reaches one, or full membership for that set. The upper and lower limits are those points at which the degree of membership reaches zero, or no membership.

Fuzzy set for the range is classified as shown in table:

Table 4.6 The linguistic importance scale

Range	Trapmf Values	Fuzzy sets
Low	-5 - 5 (-5,-4, 4, 5)	(0,0),(1,1),(2,1),(3,1),(4,1),(5,0)
Medium	4 - 8 (4, 5, 7, 8),	(4,0),(5,1),(6,1),(7,1),(8,0)
High	7 - 10 (7, 9, 10, 12)	(7,0),(8,1),(9,1),(10,1)

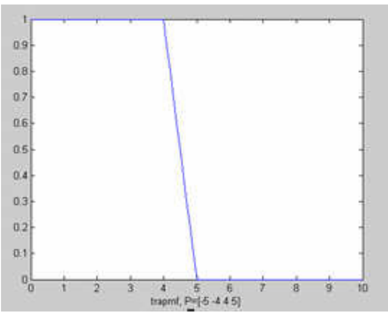


Fig. a

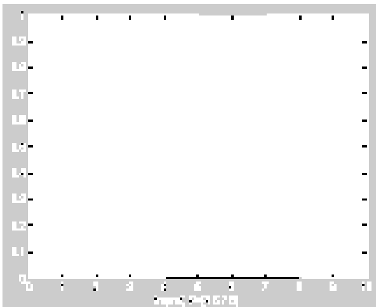


Fig. b

Fig. c

Figure (a).the membership function of Small (-5 -4 4 5) Figure (b) the membership function of Medium (4 5 7 8), Figure (c) the membership function of large (7 8 10 12) The membership function for output i.e. Improvement in Quality of Technical Education also Trap mf and is classified as Weak, Better, Superior.

Table 4.7 The linguistic importance scale

Weak	0 - 40 %
Better	30 - 70 %
Superior	60- 100 %

4.3.6 Fuzzy Rules generation

The decision which the fuzzy controller makes is derived from the rules which are stored in the database. These are stored in asset of rules. Basically the rules are if-then statement that easy to understand, as they are common English statements. Rule used here are derived from common sense. Fuzzy sets and fuzzy operators are the subjects and verbs of fuzzy logic. These if-then rules statements are used to formulate the conditional statements that comprise fuzzy logic. A single fuzzy if-then rule assumes the form if *x* is *A* then *y* is *B* where *A* and *B* are linguistic values defined by fuzzy sets on the ranges (universes of discourse) X and Y, respectively. The if- part of the rule "*x* is *A*" is called the *antecedent* or premise, while the then-part of the rule "*y* is *B*" is called the *consequent* or conclusion. Number of rules purely depends on the number of inputs. These rules are meaningful with its fuzzy linguistic representation.

Table 4.8 Relation Rules for scope of improvement of each factor

Factor	**Weight**		
	Low	**Medium**	**High**
1	Weak	Better	superior
2	Weak	Better	superior
3	Weak	Better	superior
4	Weak	Better	superior
5	Weak	Better	superior
6	Weak	Better	superior
7	Weak	Better	superior
8	Weak	Better	superior
9	Weak	Better	superior
10	Weak	Better	superior
11	Weak	Better	superior
12	Weak	Better	superior
13	Weak	Better	superior
14	Weak	Better	superior

Rules used in mat lab fuzzy tool box (Rule editor window) are shown below.

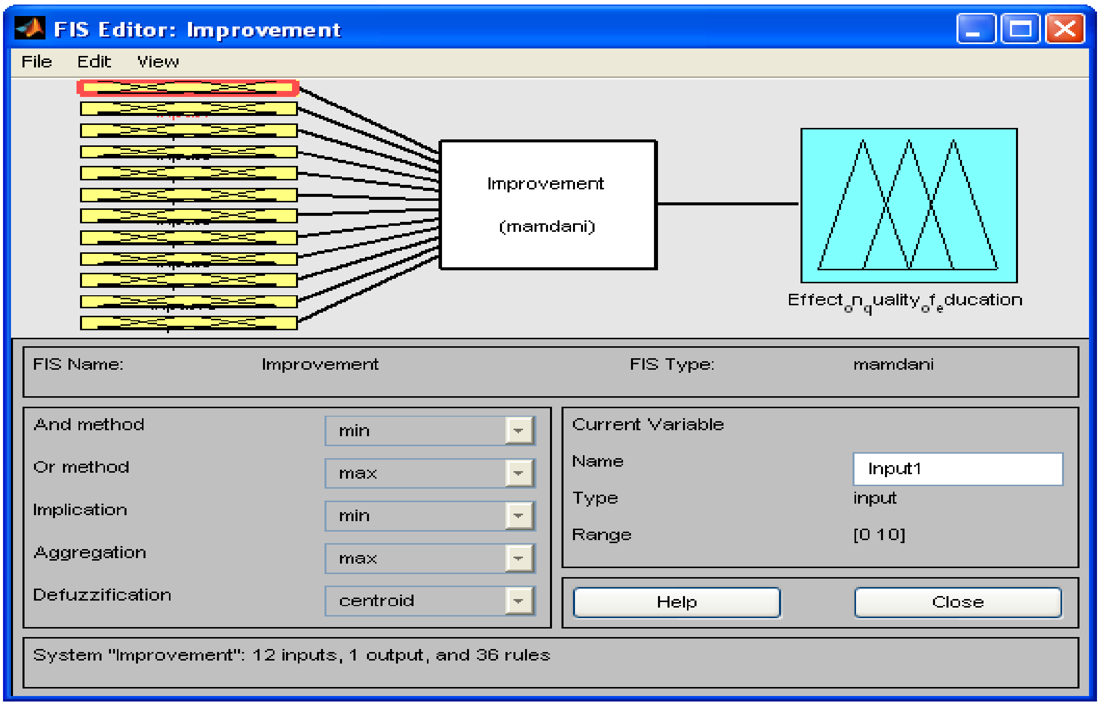
1 if Effect of “Training on state-of-the-art technology is low than Improvement in quality of education is weak” ( )
2 if Effect of “Training on state-of-the-art technology is medium than Improvement in quality of education is better” ( )
3 if Effect of “Training on state-of-the-art technology is High than Improvement in quality of education is superior” ( )

Similarly, rules for other factors can be generated.

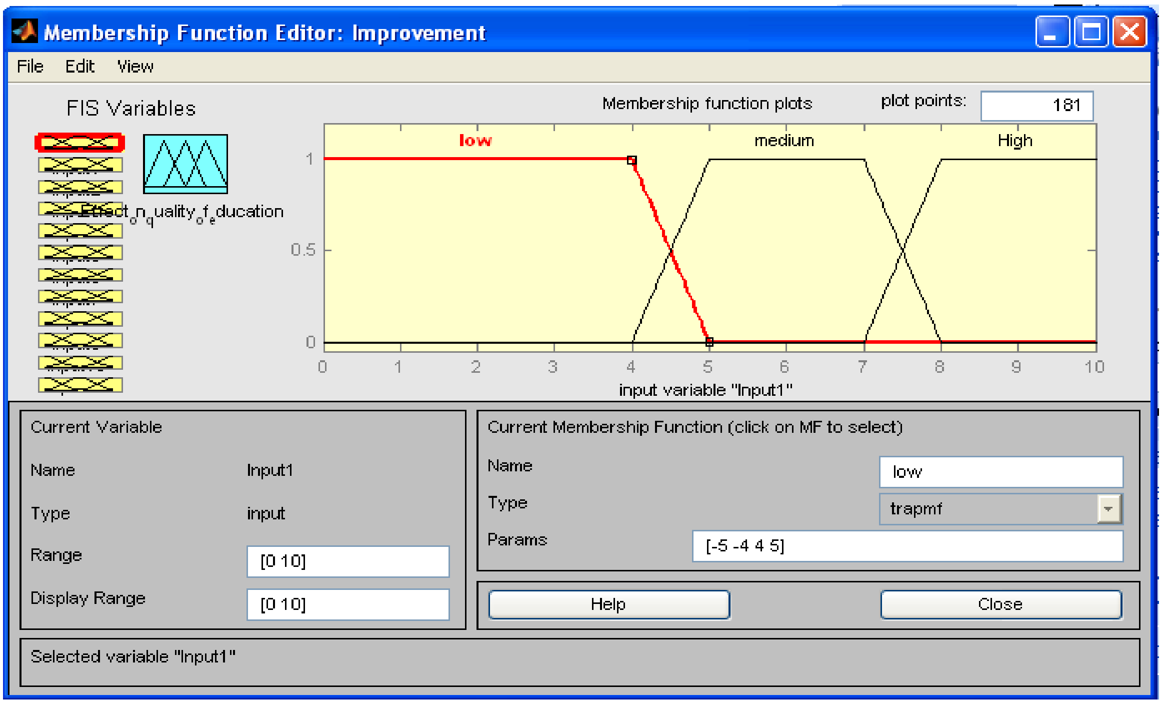
4.3.7 Result & Discussion using Fuzzy Logic Tool Box

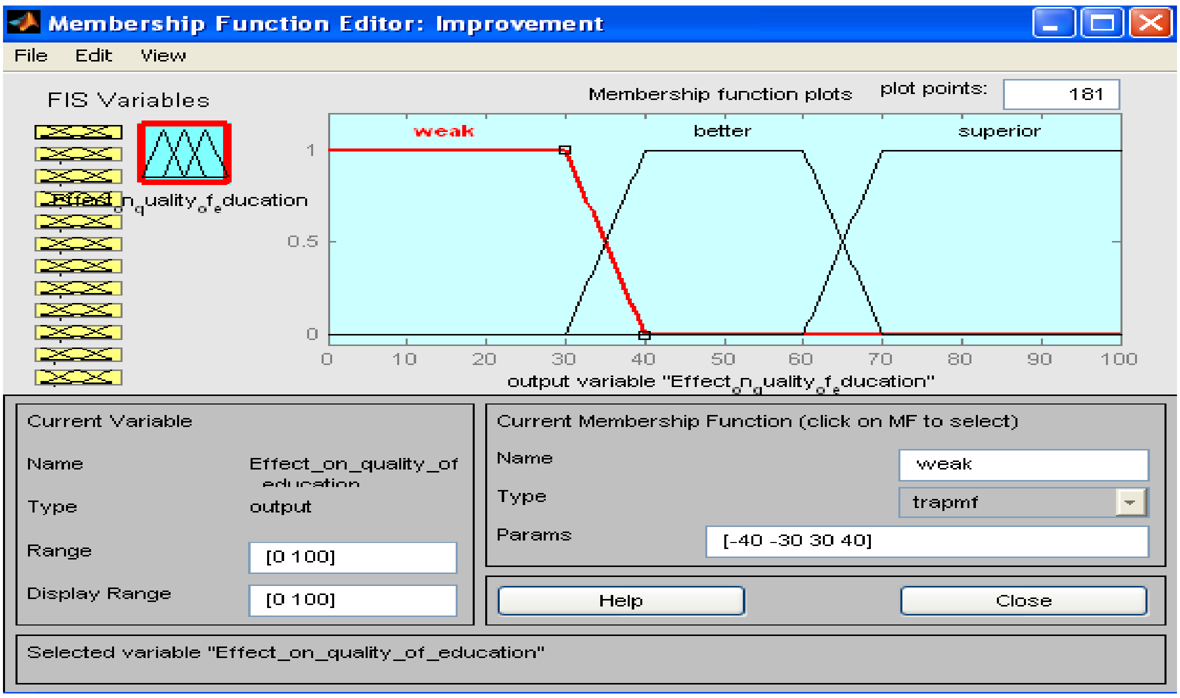
Here the input variables in fuzzy tool box of MATLAB and finding the output i.e. prediction of improvement in quality of education (Fuzzy file =Improvement)

Step 1: Here the various input variables are added as input to FIS EDITOR WINDOW as shown in figure below.

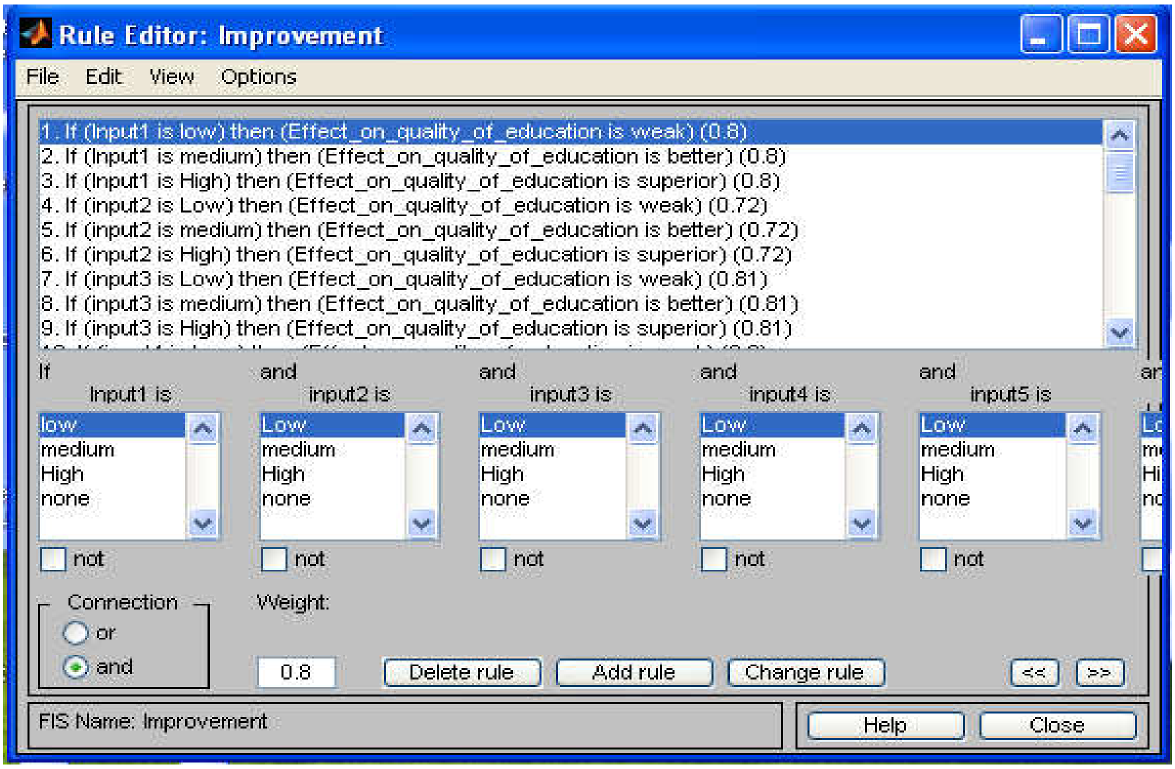


Step 2: For each input factor membership function is added. Here membership function selected is trapmf with range Small, Medium, Large As shown below. For various input (factors) and output (Improvement in Technical education).





Step 3: After adding input to FIS and generating membership function for each input next step is rule generation where rule generated for each factor based on minimum of x and y. The number of rules for each factor depends upon no of fuzzy sets. Rules are generated in rule editor window. Here we use the mean value of expert opinion as firing strength or weight age to each rule. There are around forty-two rules that are active.



Step 4: After generating rule it is easy to predict the improvement in quality of Technical education by change in effort for improvement over each factor various. Figure below shows the rule viewer window. Here we can see that by setting the each input for possible improvement in rule viewer window, the effect on out put can be observe. Impro. From figure it is clear that when effort on each individual factor is made around 7 or 8(Factor-1:7.72, Factor-2:7.72, Factor-3:7.28, Factor-4:7.28,……….) then improvements in quality would be 65.6 %.

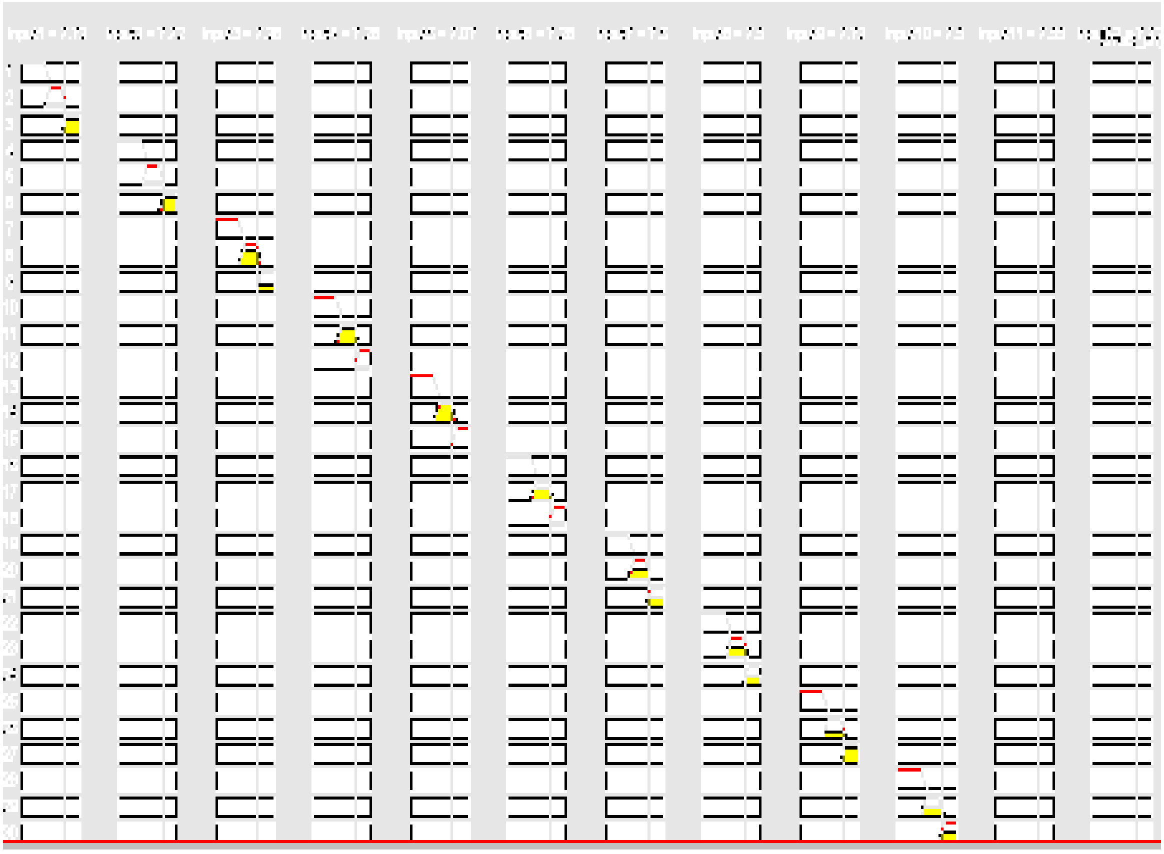


Figure 4.2 Rule Viewers (Effect of Input)

Effect on Quality of Education is 65.6

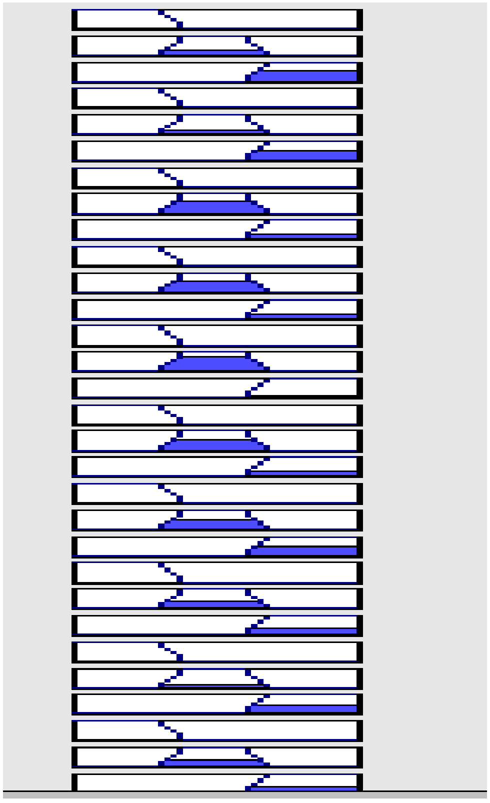


Fig. Rule Viewer (Output)

Step 5: Surface viewer: figure below shows the effect of two highly favored factors (Adaptability to Modern Techniques & Well equipped laboratories with modern facilities) by experts with their effect on Improvement in quality of education. The fig. suggest that if both the factor rated around 10 then improvement in quality of education will be around 70%. Hence these are the most critical factors which must be paid attention very much regarding upgrading the standard of education.

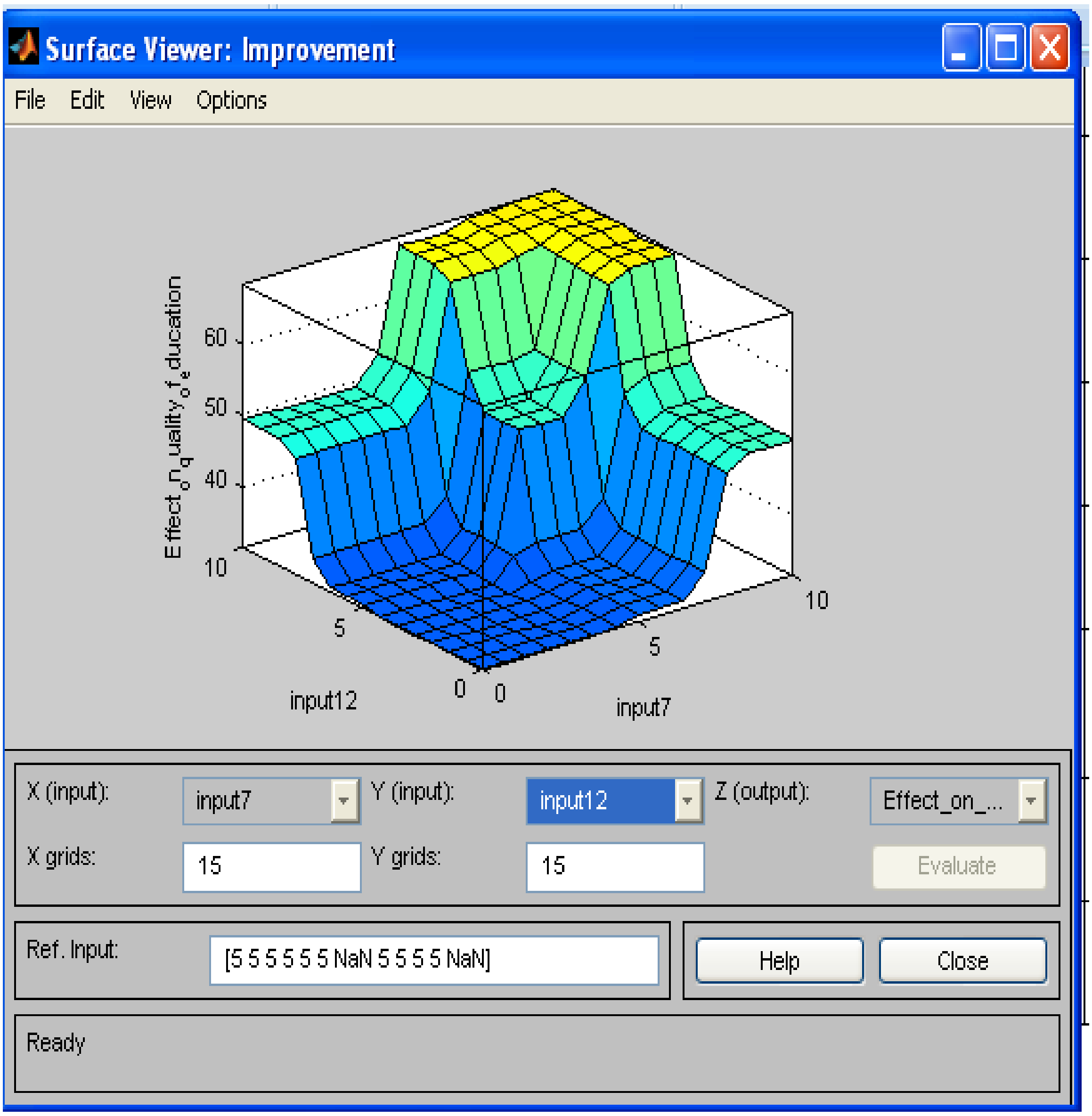


Figure 4.3 Surface Viewer-Surface relation between two most critical factors & output

4.3.8 Conclusions

A non traditional approach has been proposed to infer statistical and Fuzzy rules from quantitative database. Each factor was assigned with several fuzzy sets. Using fuzzy set concepts, fuzzy rules were inferred then Mat Lab Fuzzy logic tool box is used for generating rules. Sufficient number of parameters are used for the analysis. This approach suggests that for decision taken is very effective and useful with less mental fatigue for improving the quality in technical education.

4.4 Case study No. 3-Predicting Student's Campus Placement using Fuzzy Logic (MATLAB)

4.4.1 Introduction

Real life problem was selected from the placement cell of a reputed institute from where the datas of previous five years were collected and to these fuzzy logic was applied to assess the final number of students taken by the company. The data was taken from a placement cell of a govt. engineering institute of NCR region..

4.4.2 Fuzzy implementation

This includes the decision about

a) Input and output variables.
   (X= grade of companies),(Y=Student placed in previous year),(Z=Expected recuritment for the current year)
b) Fuzzy sets.
c) Membership functions
d) Rule generation
e) Crisp form of out put variables

After deciding input and output variables,various rules and a relational rule table was made. The following examle explains a relational table shown below between variables X and Y, that shows the output relations for different combinations of inputs.

Table 4.9 Scale used

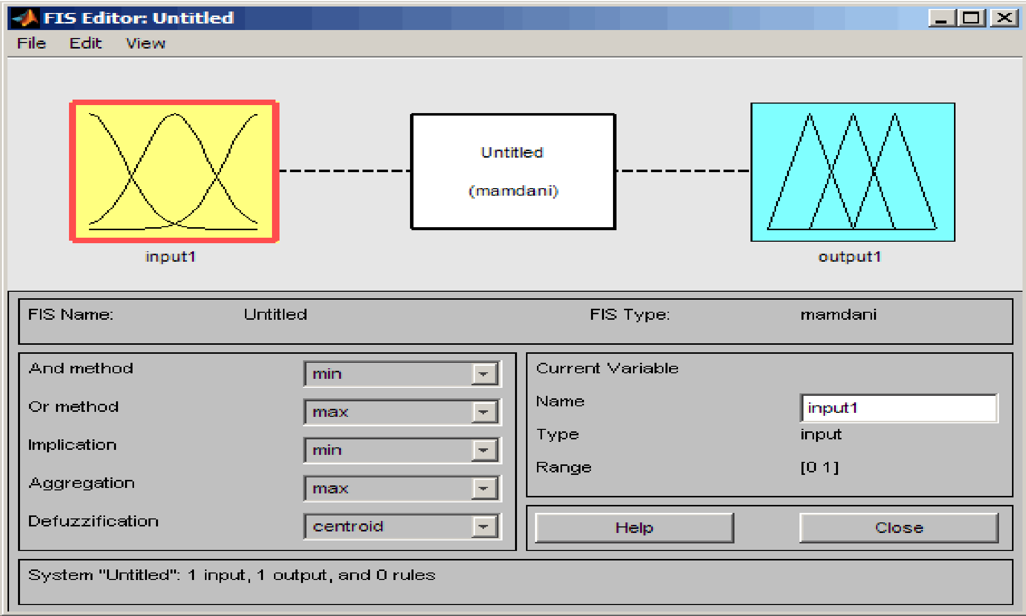
X(↓)/Y(→)	High	Medium	Low
High	High	High	Medium
Medium	High	Medium	Low
Low	High	Low	Low

Now, according to table 4.9, "If X is Medium and Y is Low then Z is Low"

4.4.3 Implementation of MATLAB (Fuzzy Logic Toolbox) for Prediction of Student Recruitment

The procedure is as below:

a) Open MATLAB, go to toolboxes, and select fuzzy logic toolbox, and the following window will open.

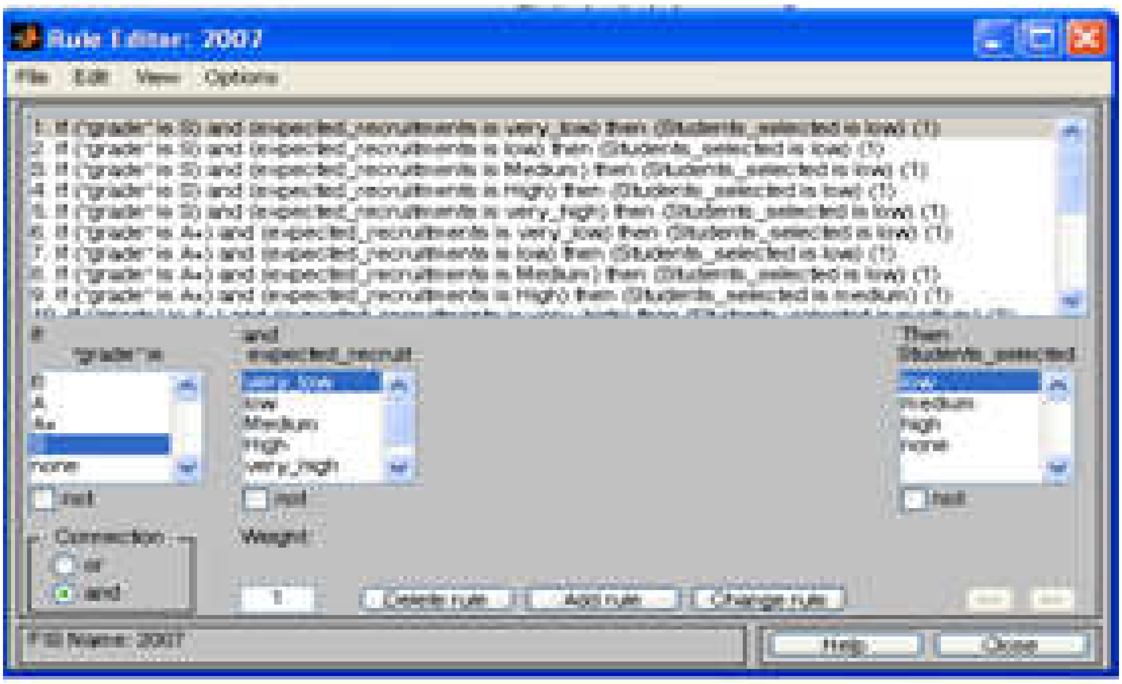


b) Now, click on input as written in the middle window of the figure. Then the membership function editor will open. Plot the membership function v/s the variable graph.In the given problem grade pay was plot against membership fuction and according to pay, reputation etc.the grade B, A, A+ and S were decided for the companies.

c) Now, add another input variable and plot the variation of another variable with respect to membership function.In this problem, number of students placed collected on the basis of previous placements is plot versus the membership function for fuzzy sets of very low, low, medium, high, very high range.

d) Similarly, the output variable is also plotted. In the given case, output variable is the expected recutiment.

e) Now, in a rule editor window using the relational rule table, define the rules.The rules can be added , changed and deleted.



(f) Now using rule viewer window effect of input on out put can be viewed.

4.4.4 Placement 2010 data

Table 4.10: Placements 2010

S NO.	Company	Package(2010)	Grade of company	Students Placed(2009)	Students placed(2010)
1	TCS	3.33	A	23	35
2	INFOSYS	3.5	A	23	33
3	MARUTI	4.5	A+	20	11
4	MICROSOFT	10.0	S	4	2
5	COGNIZANT	3.25	A	25	36
6	MOTOROLA	5.0	A+	4	11

7	L&T	4.0	A+	20	11
8	CISCO	8.0	A+	4	2
9	YAHOO	9.5	A+	3	2
10	FLEXTRONICS	3.75	A	22	24
11	ACCENTURE	3.5	A	22	30
12	D.E SHAW	12.0	S	3	2
13	IBM	4.0	A	4	11
14	WIPRO	3.15	A	23	35
15	MENTOR GRAPHICS	6.75	A+	4	2
16	INDUCTIS	4.0	A	21	11
17	FREESCALE	5.2	A+	4	11
18	ATRENTA	6.0	A+	4	10
19	AGILENT	4.50	A+	21	12
20	CONEXANT	5.5	A+	4	15
21	BECHTEL	3.80	A	23	24
22	EVALUESERVE	4.20	A+	4	11
23	SAMSUNG	4.0	A+	4	11
24	KMG	2.8	B	51	36
25	BEL	4.25	A+	4	11
26	C-DOT	4.0	A+	4	11
27	ALSTORM	3.5	A	20	30
28	M&M	3.5	A	23	31

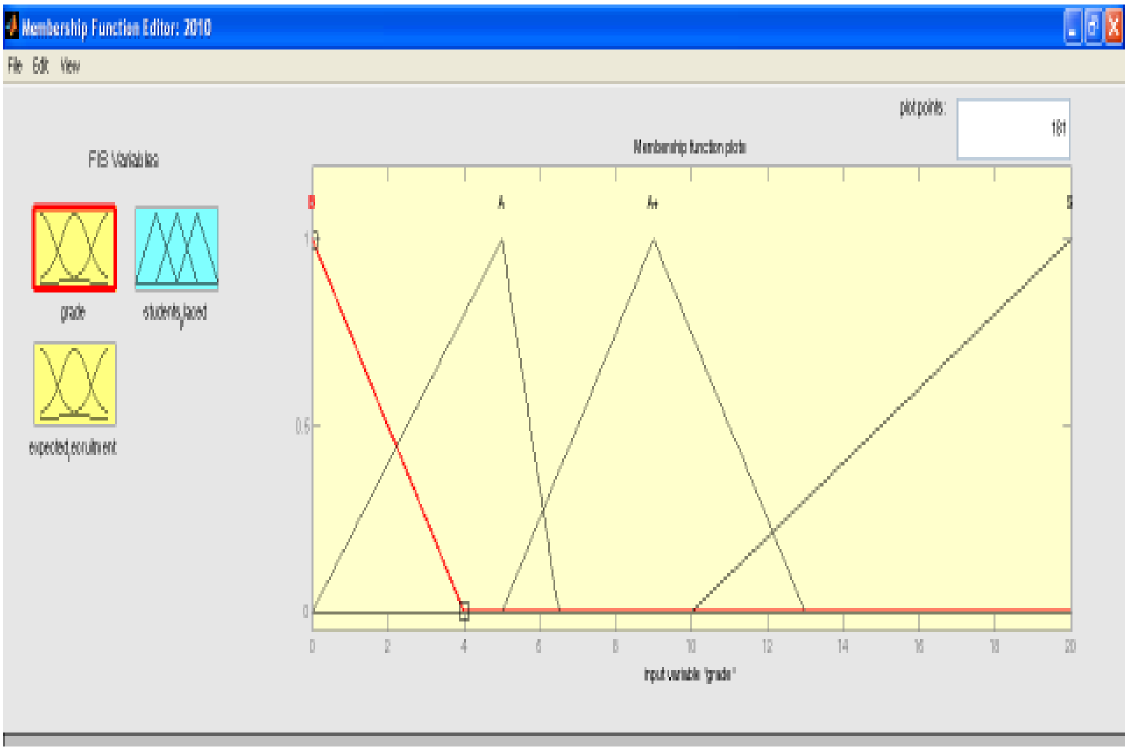
29	DELOITTE	5.0	A+	4	11
30	CSC	3.6	A	20	27
31	THE SMARTCUBE	5.0	A+	4	11
32	IOCL	6.0	A+	4	9
33	GRAIL RESEARCH	6.25	A+	3	8
34	FUTUREFIRST	6.0	A+	4	10
35	ENGINEERS INDIA LTD	5.25	A+	2	2
36	TATA MOTORS LTD	5.0	A+	4	11
37	PHILIPS	5.5	A+	4	10
38	INDUSVALLEY PARTNER	5.5	A+	3	7
39	BPCL	6.6	A+	4	2
40	SIEMENS POWER	3.75	A	4	11
41	PATNI COMPUTERS	2.4	B	23	39
42	HLS ASIA	8.0	A+	3	2
43	MINDA INDUSTRIES	2.04	B	17	39
44	CITI FINANCIAL	4.5	A+	4	11
45	GOOGLE	8.5	A+	3	2
46	FLEXTRONICS	2.85	B	20	36
47	INTEL	4.1	A	4	11
48	VSNL	3.3	A	20	32

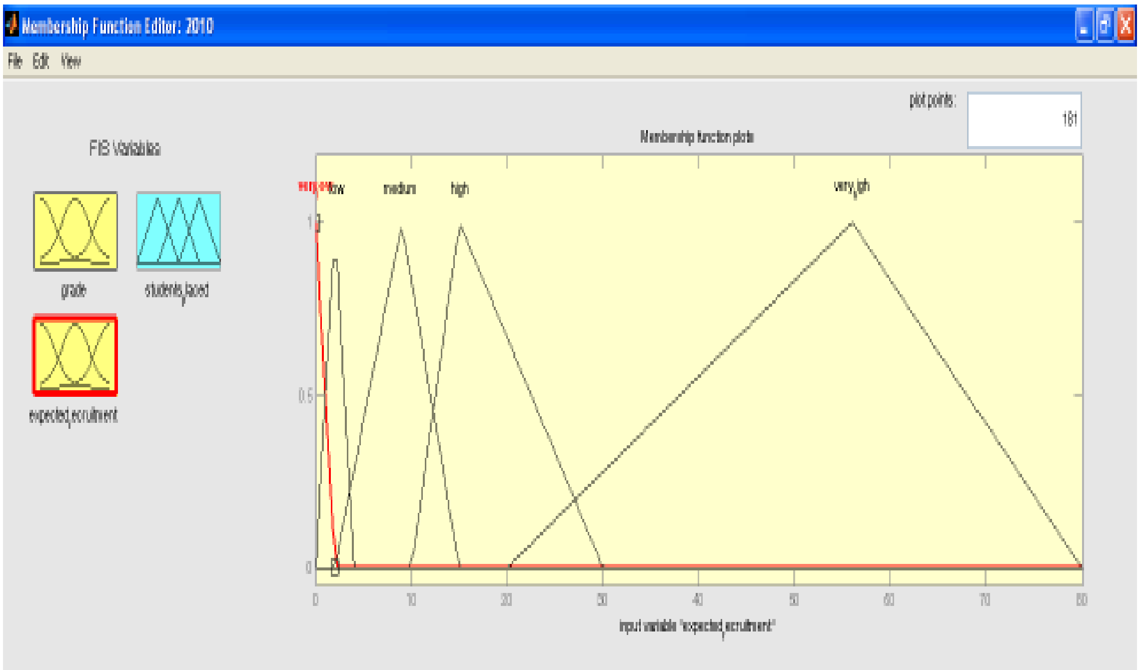
49	IRCON INTERNATIONAL	3.4	A	4	11
50	CAMPUS CONNECT	6.0	A+	4	9
51	HCL	3.0	A	4	11
52	IOCL	6.8	A+	1	2
53	BHEL	5.0	A+	4	10
54	ORACLE	8.0	A+	0	2
55	IBM	3.75	A	4	11
56	RANBAXY	5.5	A+	3	7
57	RELIANCE INFRASTRUCTURE	4.50	A+	5	11
58	HI TECH ROBO	4.0	A+	2	2
59	COCA COLA	4.5	A+	5	11
60	ONE97	5.0	A+	7	10
	BRANCH WISE TOTAL				855

Total No. of students = 900

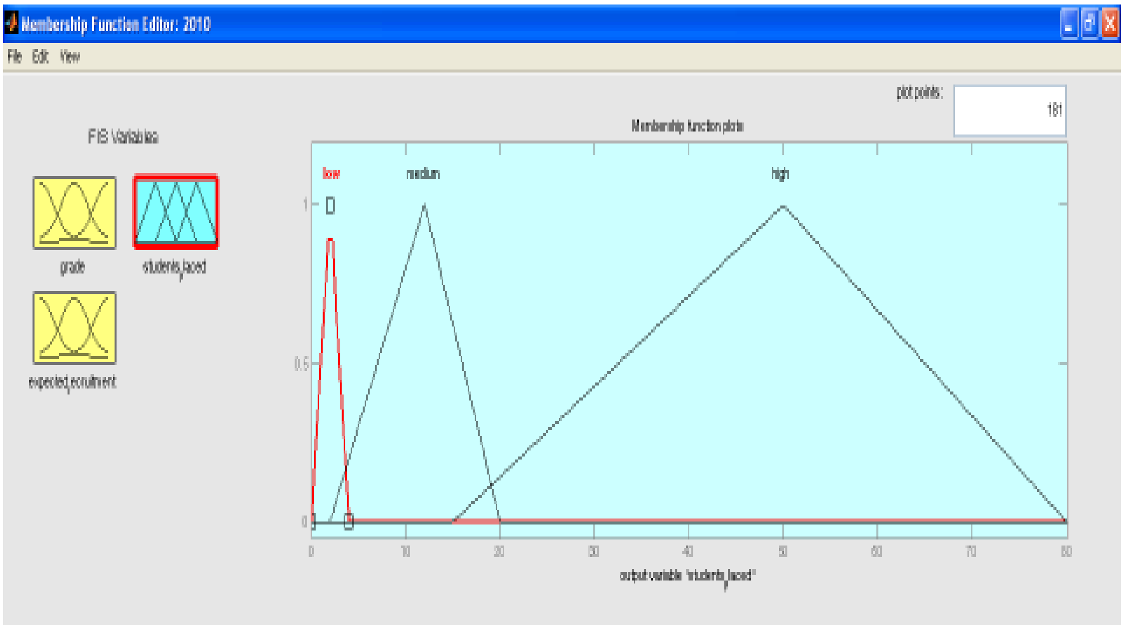
Total No. of B.E. placements = 855

Step1: Partitioning of Input variables





Step 2: Partitioning of Output variables

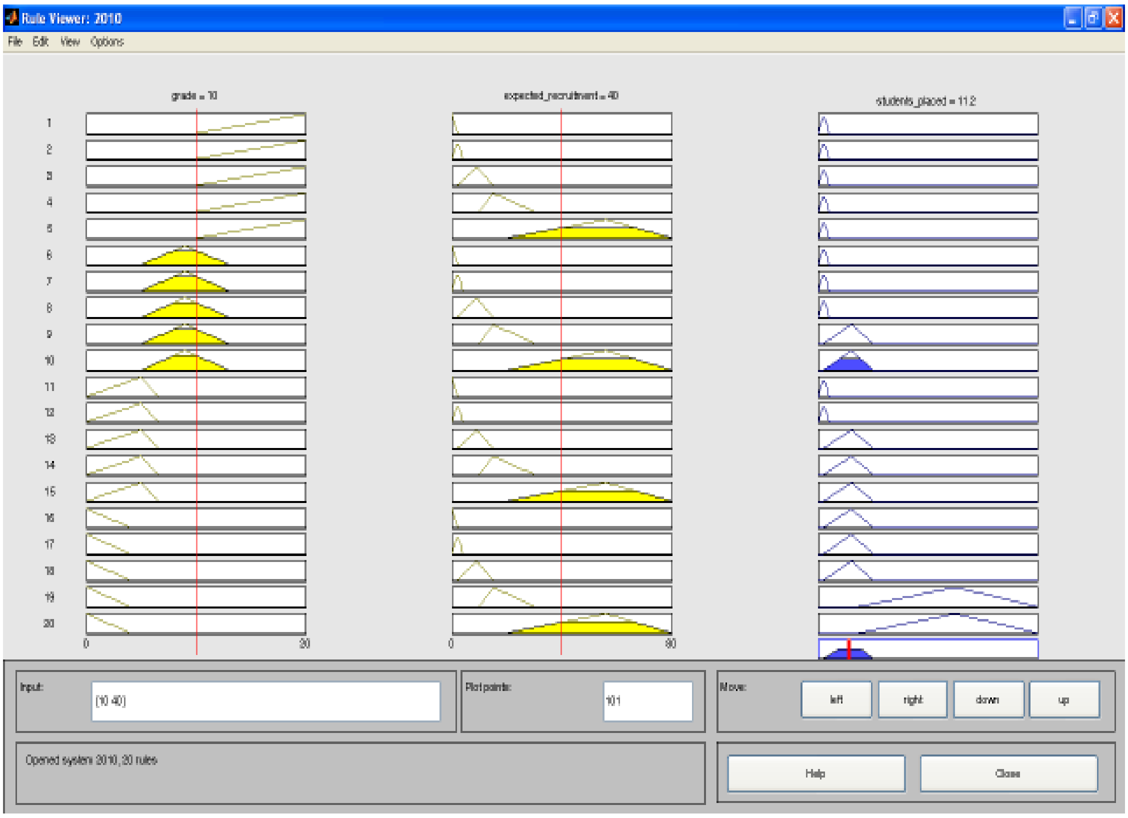


Step 3: Relational Rules

Table 4.11 Relational Rule for Calculating the Total Students who will get placed

Grade of company (↓)	Expected recruitments (→)	Very low	Low	Medium	High	Very High
S		Low	Low	Low	Low	Low
A+		Low	Low	Low	Medium	Medium
A		Low	Low	Medium	Medium	Medium
B		Medium	Medium	Medium	High	Very high

Step 4: Result (Placement 2010)



4.4.5 Placement 2009 data

Table 4.12: Placements 2009

SL NO.	Company	Package(2009)	Grade of company	Students Placed(2008)	Students placed(2009)
1	TCS	3.15	A	39	25
2	INFOSYS	3.25	A	38	27
3	MARUTI	3.25	A	11	15
4	MICROSOFT	10	S	2	4
5	COGNIZANT	3.0	A	38	25
6	MOTOROLA	4.75	A+	11	4

7	L&T	3.45	A	12	20
8	CISCO	8.0	A+	11	4
9	YAHOO	8.5	A+	2	3
10	FLEXTRONICS	3.50	A	10	22
11	ACCENTURE	3.15	A	10	22
12	D.E SHAW	10	S	2	3
13	IBM	3.75	A	11	4
14	WIPRO	3.0	A	35	23
15	MENTOR GRAPHICS	6.5	A+	2	4
16	INDUCTIS	3.75	A	19	21
17	FREESCALE	5.5	A+	11	4
18	ATRENTA	5.5	A+	2	4
19	AGILENT	4.3	A+	20	21
20	CONEXANT	5.0	A+	11	4
21	BECHTEL	3.20	A	11	23
22	EVALUESERVE	5.0	A+	13	4
23	SAMSUNG	5.0	A+	11	4
24	KMG	2.65	A	44	51
25	BEL	3.9	A	5	4
26	C-DOT	4.2	A+	11	4
27	ALSTORM	3.20	A	11	20
28	M&M	3.0	A	12	23

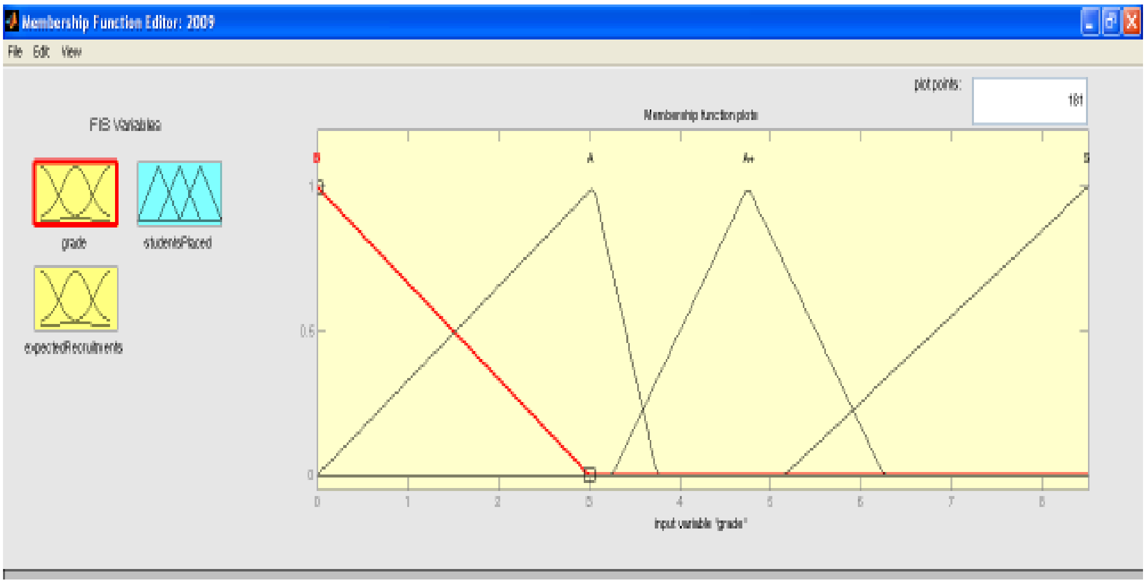
29	DELOITTE	4.4	A+	9	4
30	CSC	3.75	A	17	20
31	THE SMARTCUBE	5.2	A+	11	4
32	IOCL	5.50	A+	11	4
33	GRAIL RESEARCH	6.0	A+	10	3
34	FUTUREFIRST	6.4	A+	9	4
35	ENGINEERS INDIA LTD	5.0	A+	11	2
36	TATA MOTORS LTD	5.30	A+	11	4
37	PHILIPS	5.2	A+	2	4
38	INDUSVALLEY PARTNER	5.4	A+	11	3
39	BPCL	6.4	A+	11	4
40	SIEMENS POWER	4.0	A+	12	4
41	PATNI COMPUTERS	3.25	A	29	23
42	HLS ASIA	8.0	A+	2	3
43	MINDA INDUSTRIES	2.04	B	10	17
44	CITI FINANCIAL	4.5	A+	11	4
45	GOOGLE	8.5	A+	2	3
46	FLEXTRONICS	2.85	B	9	20
47	INTEL	4.1	A	10	4

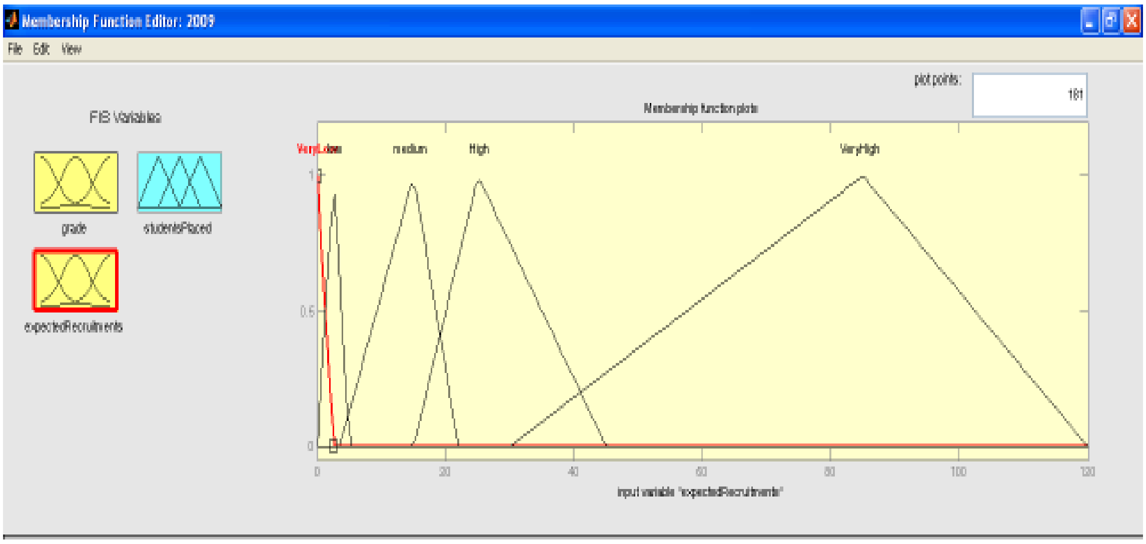
48	VSNL	3.3	A	11	20
49	IRCON INTERNATIONAL	4.5	A+	11	4
50	CAMPUS CONNECT	6.0	A+	2	4
51	MANHATTAN ASSOCIATES	5.0	A+	2	4
52	MCKINSEY	8.0	S	1	4
53	RELIANCE ENERGY	4.5	A+	15	5
54	TERI	5.0	A+	12	4
55	DRDO	4.0	A+	7	4
56	ARICENT	3.5	A+	50	24
57	ASHOK LEYLAND	3.1	A	25	23
58	HCL TECH	3	A	20	23
59	LG ELECTRONICS	3.5	A+	5	15
60	BHEL	4.0	A+	15	4
	BRANCH WISE TOTAL			637	663

Total No. of students = 700

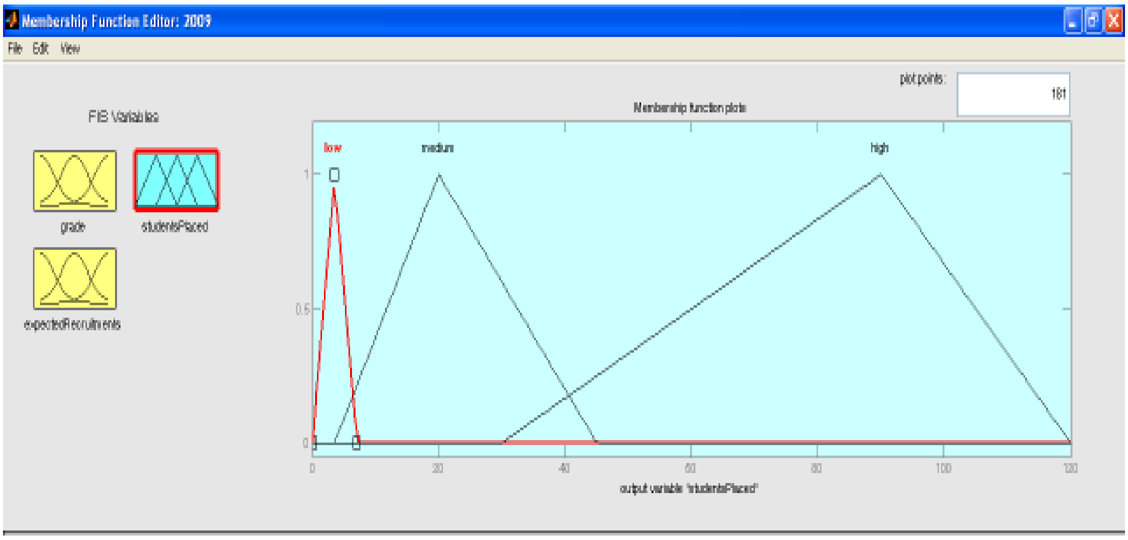
Total No. of B.E. placements = 663

Step 1: Partitioning of Input variables





Step 2: Partitioning of Output variables

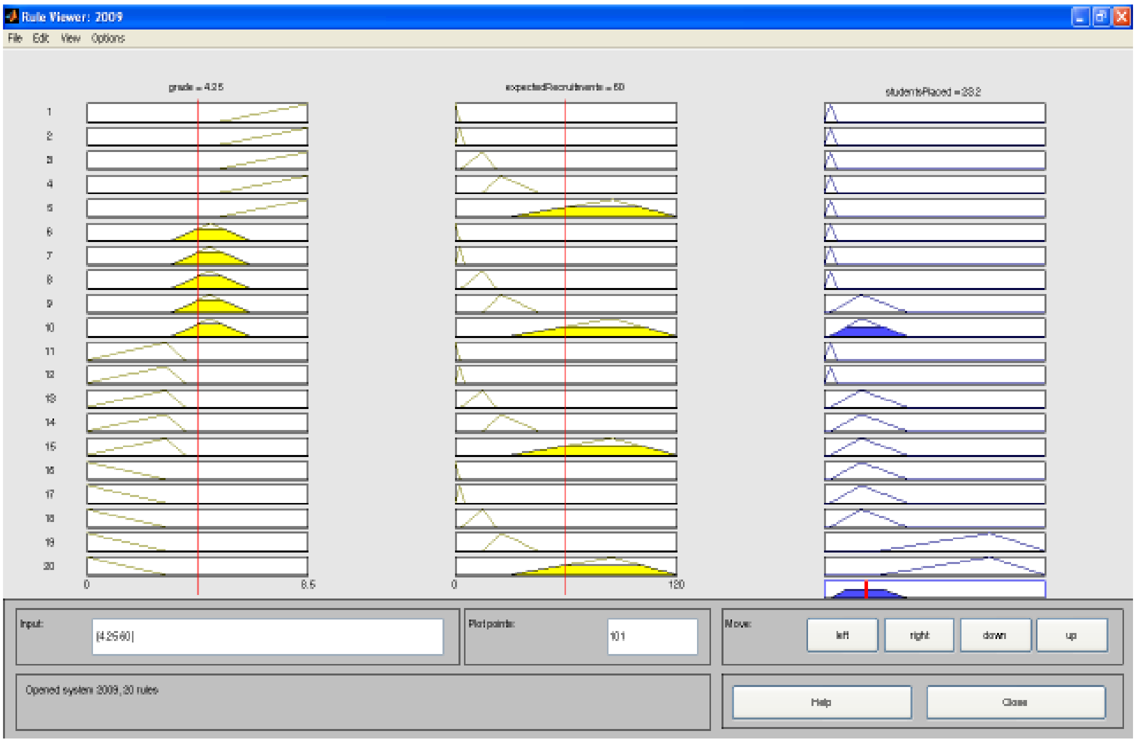


Step 3: Relational Rule

Table 4.13 Relational Rule for Calculating the Total Students who will get placed

Grade of company (↓)	Expected recruitments (→)	Very low	Low	Medium	High	Very High
S		Low	Low	Low	Low	Low
A+		Low	Low	Low	Medium	Medium
A		Low	Low	Medium	Medium	Medium
B		Medium	Medium	Medium	High	Very high

Step 4: Rule Viewer window to predict the Result for (Placement 2009)



4.4.6 Placement 2008 Data

Table 4.14: Placements 2008

SL NO.	Company	Package(2008)	Grade of company	Students placed (2007)	Students placed(2008)
1	TCS	2.7	A	35	41
2	INFOSYS	2.7	A	36	32
3	MARUTI	2.75	A	10	12
4	MICROSOFT	9.15	S	2	2
5	COGNIZANT	2.7	A	35	38

6	MOTOROLA	4.20	A+	11	11
7	L&T	2.7	A	10	12
8	CISCO	4.77	A+	10	11
9	YAHOO	8.0	A+	2	2
10	FLEXTRONICS	3.1	A	10	10
11	ACCENTURE	2.7	A	10	10
12	D.E SHAW	9.04	A+	2	2
13	IBM	3.3	A	10	11
14	WIPRO	2.5	B	26	35
15	MENTOR GRAPHICS	5.9	A+	2	2
16	INDUCTIS	3.0	A	11	19
17	FREESCALE	4.4	A+	10	11
18	ATRENTA	5.3	A+	2	2
19	AGILENT	3.5	A	11	20
20	CONEXANT	4.5	A+	11	11
21	BECHTEL	3.25	A	10	11
22	EVALUESERVE	4.01	A+	10	13
23	SAMSUNG	5.0	A+	11	11
24	KMG	2.1	B	33	44
25	BEL	3	A	2	5
26	C-DOT	3.9	A+	10	11
27	ALSTORM	2.4	A	8	11

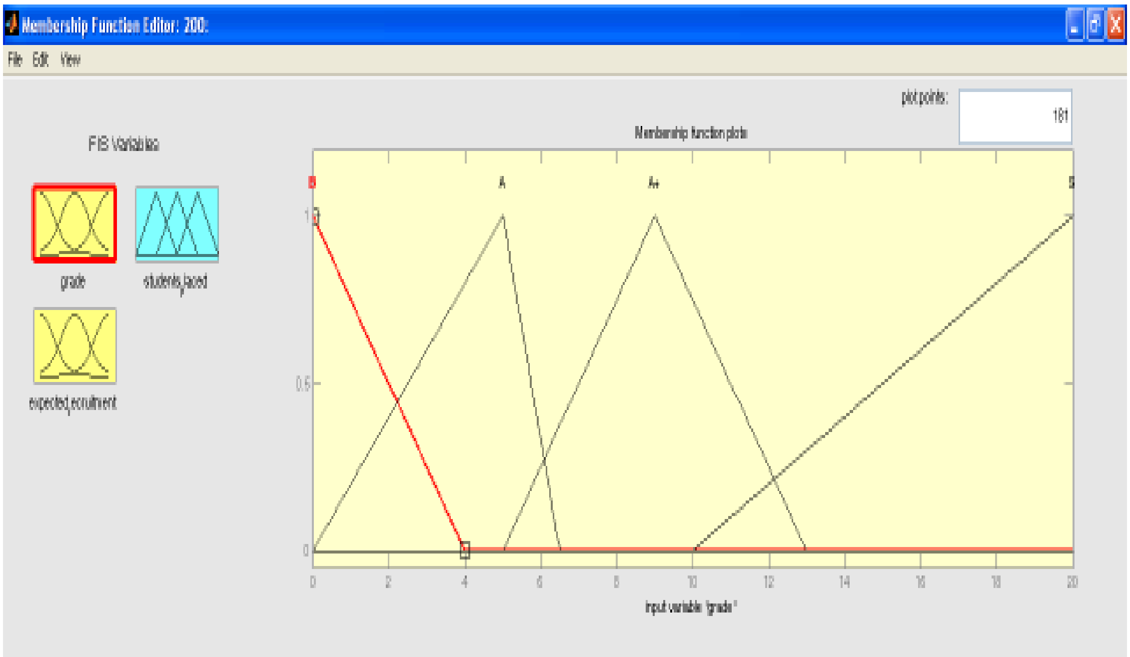
28	M&M	3.0	A	10	12
29	DELOITTE	3.54	A+	9	9
30	CSC	3.9	A+	11	17
31	THE SMARTCUBE	4.8	A+	8	11
32	IOCL	5.4	A+	10	11
33	GRAIL RESEARCH	6.0	A+	9	10
34	FUTUREFIRST	4.5	A+	9	9
35	ENGINEERS INDIA LTD	4.8	A+	10	11
36	TATA MOTORS LTD	4.7	A+	8	11
37	PHILIPS	5.0	A+	2	2
38	INDUSVALLEY PARTNER	5.0	A+	10	11
39	BPCL	5.17	A+	10	11
40	SIEMENS POWER	3.6	A+	9	12
41	PATNI COMPUTERS	2.4	B	20	29
42	HLS ASIA	8.0	A+	2	2
43	MINDA INDUSTRIES	2.04	B	8	10
44	CITI FINANCIAL	4.5	A+	10	11
45	GOOGLE	8.5	A+	2	2
46	FLEXTRONICS	2.85	A	10	9

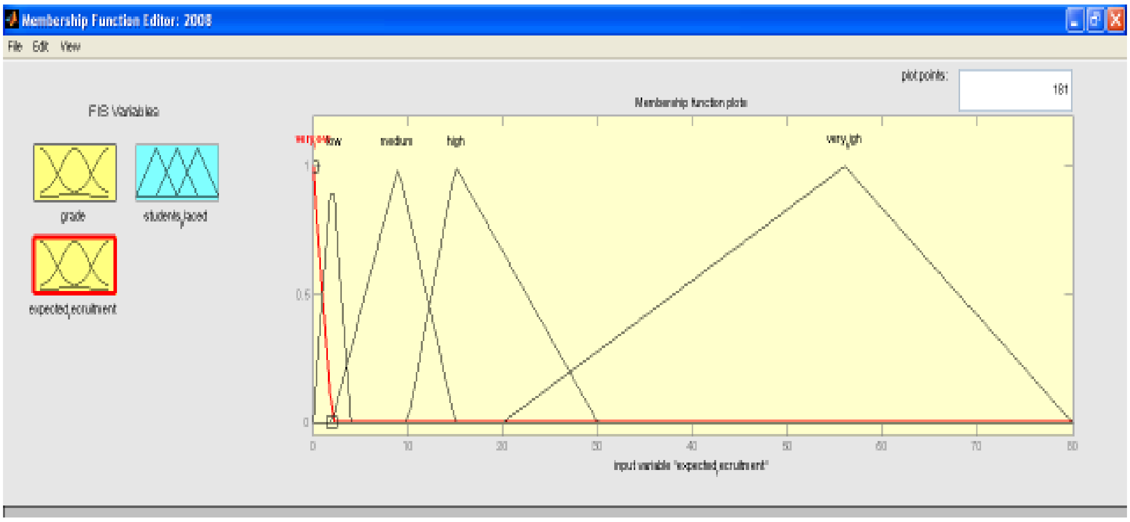
47	INTEL	4.1	A+	8	10
48	VSNL	3.3	A	8	11
49	IRCON INTERNATIONAL	3.4	A	9	11
50	CAMPUS CONNECT	6.0	A+	2	2
	BRANCH WISE TOTAL			534	637

Total No. of students = 700

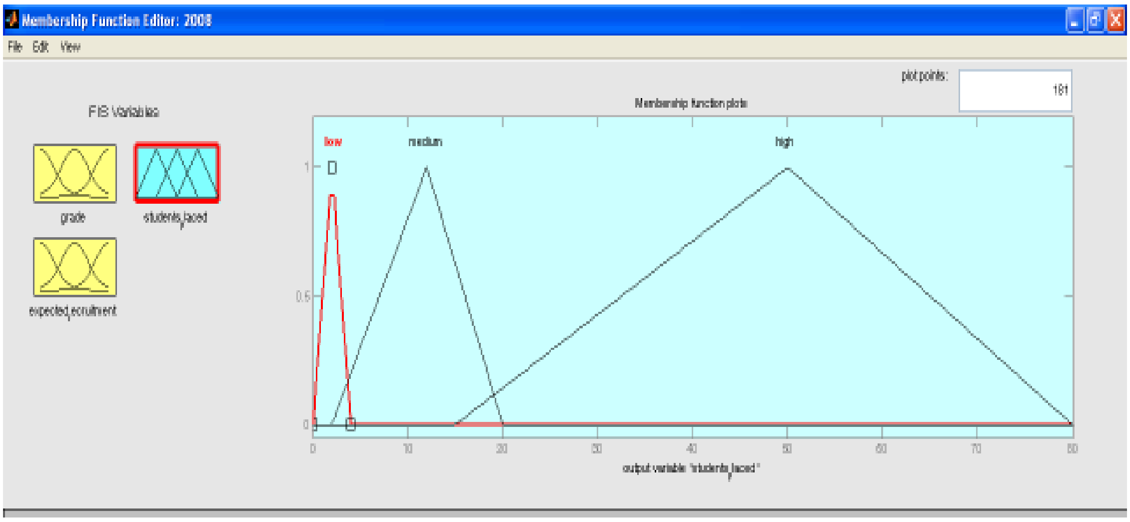
Total No. of B.E. Placements = 637

<u>Step 1: Partitioning of Input variables</u>





Step 2: Partitioning of Output variables

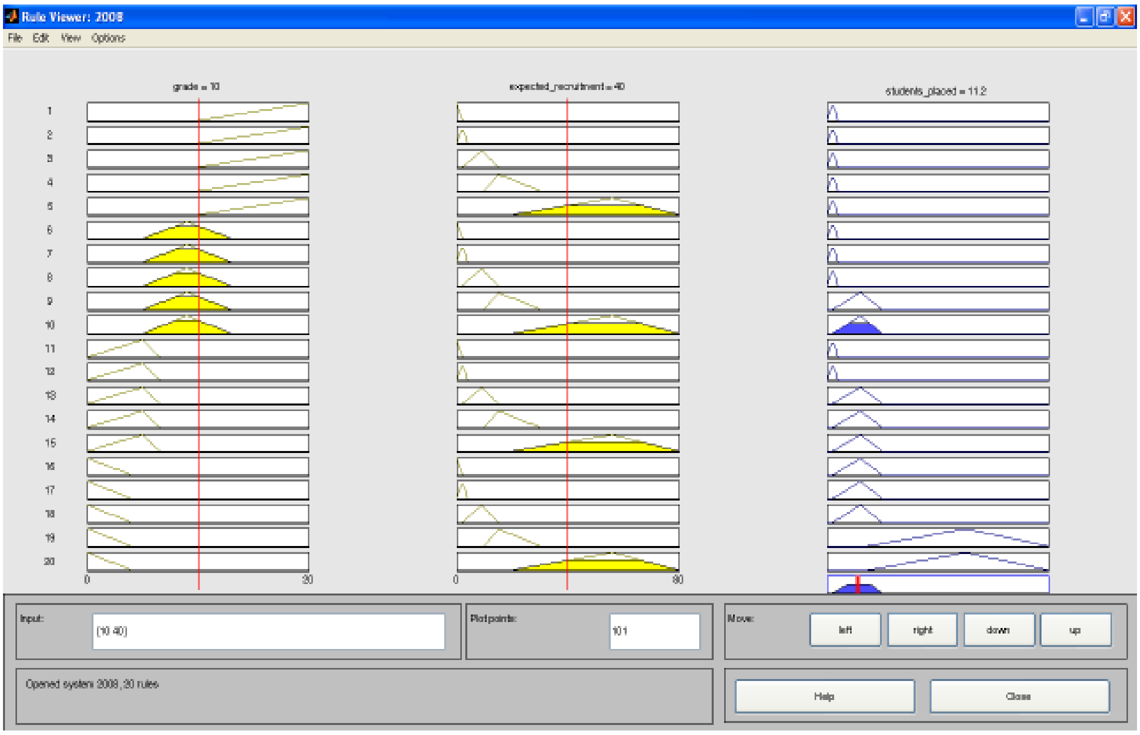


Step 3: Relational Rule

Table 4.15 Relational Rule for Calculating the Total Students who will get placed

Grade of company (↓)	Expected recruitments (→)	Very low	Low	Medium	High	Very High
S		Low	Low	Low	Low	Low
A+		Low	Low	Low	Medium	Medium
A		Low	Low	Medium	Medium	Medium
B		Medium	Medium	Medium	High	Very high

Step 4: Rule Viewer to predict the Result (Placement 2008)



4.4.7 Placement 2007 Data

Table 4.16: Placements 2007

SL NO.	Company	Package(2007) (In Rs. LPA)	Grade of company	students placed (2006)	Students placed(2007)
1	TCS	2.0	B	33	37
2	INFOSYS	2.04	B	30	35
3	MARUTI	2.75	A	7	12
4	MICROSOFT	5.8	A+	2	2
5	COGNIZANT	2.11	B	30	35
6	MOTOROLA	4.0	A	7	15
7	L&T	2.5	B	8	10
8	CISCO	4.5	A+	9	10
9	YAHOO	7.5	A+	2	2
10	FLEXTRONICS	2.75	B	14	10
11	ACCENTURE	2.5	B	12	10
12	D.E SHAW	6.5	A+	3	2
13	IBM	4.25	A	7	10
14	WIPRO	2.3	B	17	26
15	MENTOR GRAPHICS	5.4	A+	1	2
16	INDUCTIS	3	A	9	11
17	FREESCALE	4.1	A	5	10
18	ATRENTA	5.5	A+	2	2

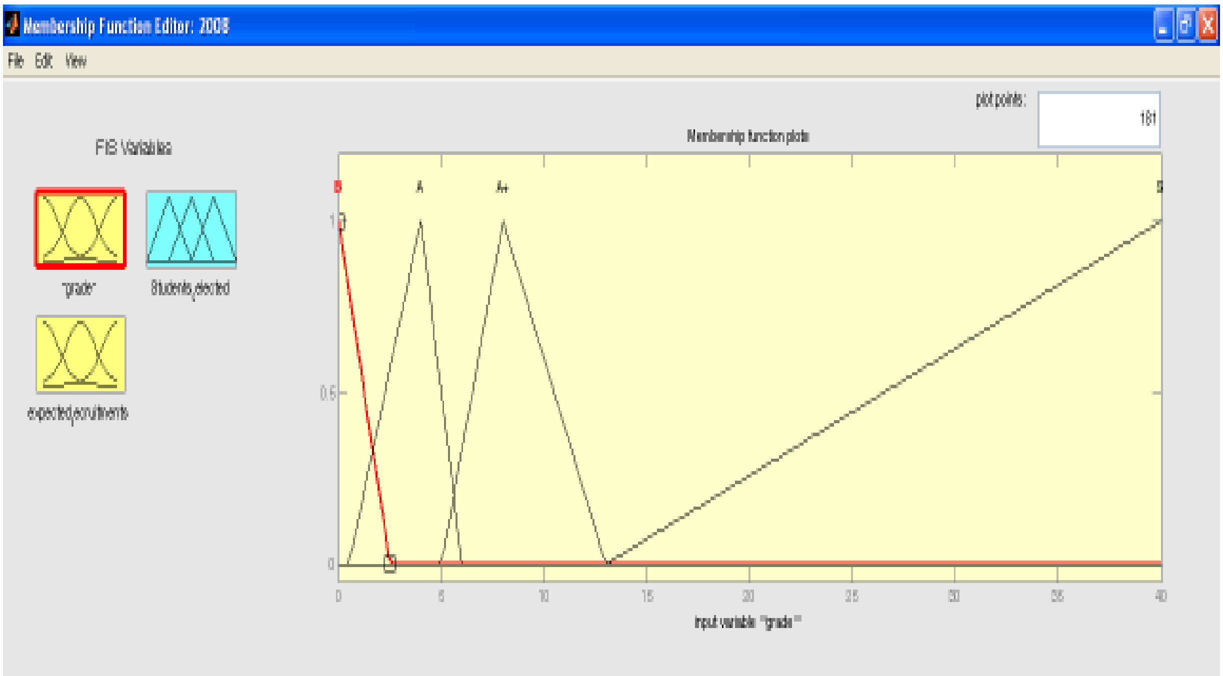
19	AGILENT	3.5	A	5	11
20	CONEXANT	4.5	A+	9	11
21	BECHTEL	3.0	A	8	10
22	EVALUESERVE	4.01	A+	18	10
23	SAMSUNG	3.5	A	10	11
24	KMG INFO	2.1	B	25	33
25	BEL	2.25	B	1	2
26	C-DOT	4.0	A+	7	10
27	ALSTORM	2.4	B	4	8
28	M&M	2.75	A	7	10
29	DELOITTE	3.25	A+	6	9
30	CSC	3.21	A+	9	11
31	THE SMARTCUBE	4.5	A+	3	8
32	IOCL	5.0	A+	5	10
33	GRAIL RESEARCH	5.5	A+	7	9
34	FUTURES FIRST	5.24	A+	7	9
35	ENGINEERS INDIA LTD	4.5	A+	9	10
36	TATA MOTORS LTD	5	A+	3	8
37	PHILIPS	4.5	A+	2	2
38	INDUS VALLEY PARTNER	4.5	A+	7	10

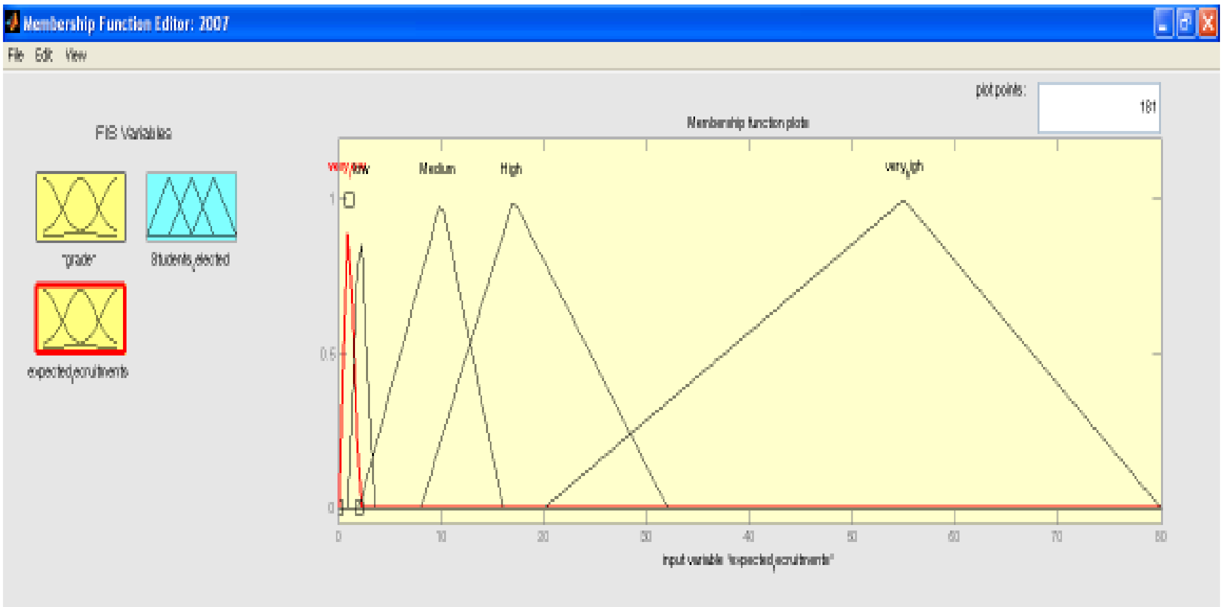
39	BPCL	5.0	A+	6	10
40	SIEMENS POWER	2.8	A	7	9
41	PATNI COMPUTERS	2.4	B	13	20
42	HLS ASIA	8.0	A+	1	2
43	MINDA INDUSTRIES	2.04	B	3	8
44	CITI FINANCIAL	4.5	A+	10	10
45	GOOGLE	8.5	A+	2	2
46	FLEXTRONICS	2.85	A	14	10
47	INTEL	4.1	A+	4	8
48	VSNL	3.3	A	3	8
49	IRCON INTERNATIONAL	3.4	A	3	9
50	CAMPUS CONNECT	6.0	A+	2	2
	BRANCH WISE TOTAL			418	534

Total No. of students = 550

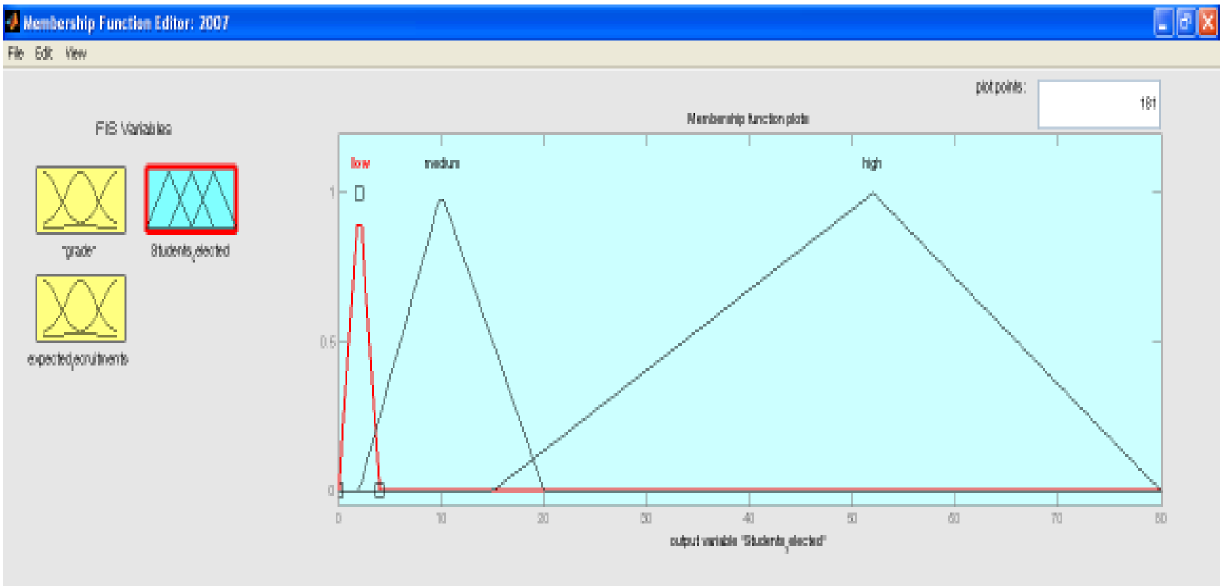
Total No. of B.E. placements = 534

Step 1: Partitioning of Input variables





Step 2: Partitioning of Output variables

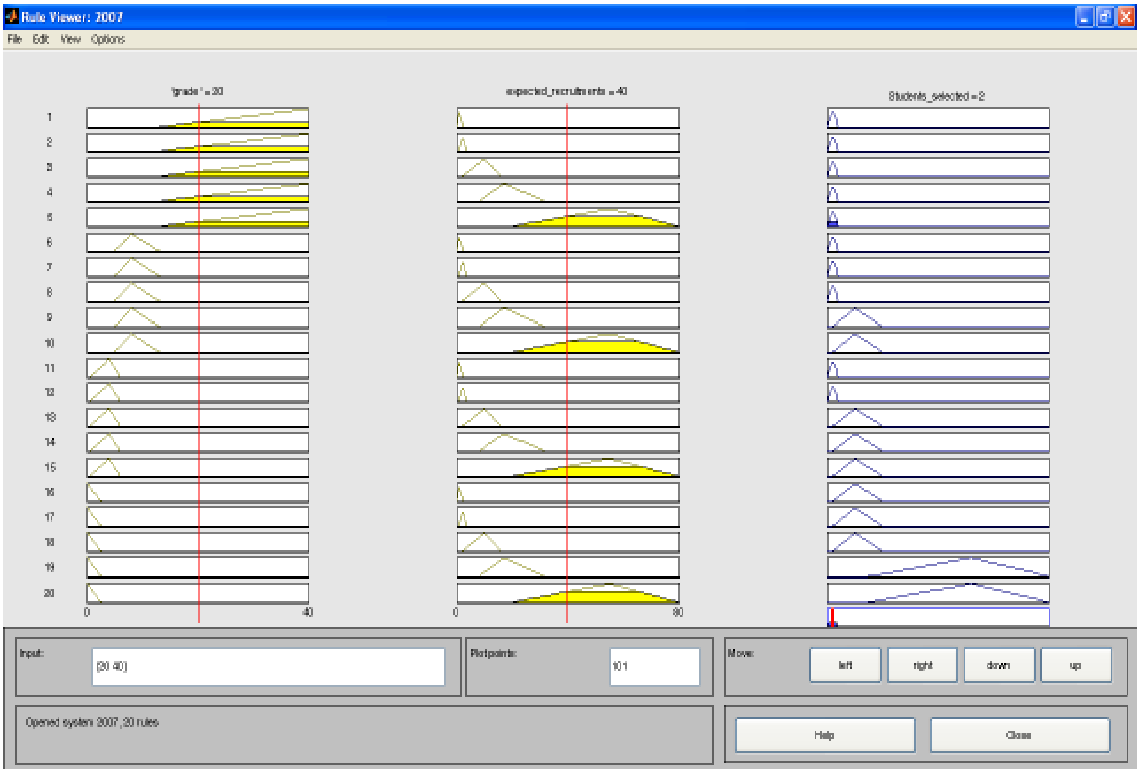


Step 3: Relational Rule

Table 4.17 Relational Rule for Calculating the Total Students who will get placed

GRADE OF COMPANY (↓)	EXPECTED RECRUITMENTS (→)	VERY LOW	LOW	MEDIUM	HIGH	VERY HIGH
S		LOW	LOW	LOW	LOW	LOW
A+		LOW	LOW	LOW	MEDIUM	MEDIUM
A		LOW	LOW	MEDIUM	MEDIUM	MEDIUM
B		MEDIUM	MEDIUM	MEDIUM	HIGH	VERY HIGH

Step 4: Rule viewer window to view the Result (Placement 2007)



4.4.8 Discussion of Results

Fuzzy logic was successfully applied to determine the placement statistics. But there are some errors in the final graph obtained. It is applicable for some values but not for the all. For example: when the grade was put equal to 20 and expected students to be equal to 80 in the placement 2008 file , the value of the number of the students selected was found to be equal to 40, which is wrong, as the rule that has been entered says.

"If the grade of company is high and the number of expected recruitments is very high, then the number of students selected should be low"

4.4.9 Conclusions

The case studies for the placements of an engineering institute have been done for the years 2007, 2008, 2009 and 2010 using Fuzzy logic –Matlab. The resulting graphs for various values of the placements have been checked at different levels for the placements. The predicted results are very much in line with actual data which proves that Fuzzy Matlab model for the prediction of the placements is quite powerful and accurate.

4.5 Case study No. 4-Application of Statistical Process Control (SPC) for Quality Management in Technical Education*

4.5.1 Introduction

SPC stands for Statistical Process Control,in which the statistical technology and methodology are applied to monitor the quality of product during manufacturing process in real time. It could distinguish and pick up the abnormal deviation of quality from the normal deviation scientifically and precisely, so that a certain kind of early warning could be given when an abnormal is found in manufacturing process, and a certain measures would be taken by relevant persons, e.g. try to find the causes, try to eliminate the abnormal, and try to restore a stable process, etc. it's necessary for a enterprise to achieve the targets of quality control and improving.

Walter Shewhart, the founder of SPC, had presented some famous comments on application of SPC:

- There are 2 factors appeared in deviation for all manufacturing processes, one is a stable factor, the normal deviation, which is caused by process itself and another is an interrupted factor, the abnormal deviation, which its causes could be found out."
- The abnormal deviation can be found out and eliminated by some effective methods, but the normal deviation will never be disappeared unless the basic manufacturing process is altered."
- The 3σ SPC control charts could be used to distinguish the abnormal deviation from normal deviation."

SPC is not only a tool for identifying trends or changes, but also provides relevant information whether a process is in control or not. The data obtained from questionnaire are plotted about the mean, range, or proportion. Using the appropriate control chart, one can make diagnosis about the process. If a sample exceeds a control limit, there is strong possibility that an assignable cause exists for this variation, such as major differences attributed to the implementation of a new initiative. If a sample does not exceed a limit, then sample-to-sample variation may just be due to common cause variation. By allowing variations to be examined in a logical manner, control charts can provide engineering educators with the information needed to make a systematic change.

SPC has been widely used in quality management for enterprises; it has been proved effective which relevant means of SPC are applied to monitor production process. To promote the teaching quality is one of the main objectives for colleges and universities in current period. Teaching means process.

** Part of this case study is published in Global Journal of Finance and Management Vol. 3, No. 1, 2011 PP -25-33 (ISSN 0975-6477)*

In this instance, chart for average and standard deviation, the "$\overline{X}$-S chart or $\overline{X}$ –R", is chosen to monitor and process the classes' average marks and chart for proportion of detectives, the "p chart", is chosen to monitor and process the classes' fail rate.

Before implementing SPC usually two questions should be answered, what data is to be collected and what controls is to be used under some specific circumstances. Data is collected as per need and objective.

4.5.2 Control Charts

Control charts were popularized by Walter Shewhart in his work in the 1920s at Western Electric. A control chart is a plot of measurements over time with statistical limits applied. Actually, control chart is a slight misnomer. The chart itself is really a monitoring tool. The control activity might occur if the chart indicates that the process is changing in an undesirable systematic direction.

A control chart has a center line and lower and upper control limits. The center line is in accordance with the data in the samples. It is an indication of the mean of a process and is usually found by taking the average values in the sample. Center line can be a desirable target or the standard value. The values of the statistic plotted on a control chart are assumed to have an approximately normal distribution.

The control limits are two lines, one above and one below the center line, that aid in decision making process. These limits are chosen so that the probability of the sample points falling between them is almost 1 (usually about 99.7% for 3σ limits) if the process is in statistical control.

When the SPC is applied to analyze the final examination marks, standard of 3_ will be adopted to build relevant control charts, in order to draw a control chart, some objects is defined as below:

CL: Central Line, the mean value of samples.

UCL: Upper Control Limit, the value is CL + 3σ.

LCL: Lower Control Limit, the value is CL - 3σ.

Reliability of 3σ control chart is 99.73%, that is, the occurrence possibility of type-1 error is 0.27%.

A control chart is a means of on-line process control. Data values are collected for a process and the appropriate sample statistics based on the quality characteristic of interest are obtained. These sample statistics are then plotted on the control chart and if they fall within the control limits and do not exhibit any systematic or non-random pattern, the process is judged to be in statistical control. If the control limits are calculated from the current data, the chart tells us whether the process is presently in control. If the control

limits are calculated from previous data based on a process that was in control, the chart can be used to determine whether the current process has drifted out of control.
Control charts are:
Important management tools which helps in decision making.

- They help management to set realistic goals.
- They estimate the process parameter which helps in Process Capability (the ability of the process to produce within the desirable specifications).

There are two types of control charts:

- Control Chart for Variables ($\overline{X}$ -R and $\overline{X}$ -S Control Charts)
- Control Chart for Attributes (p- chart, np- chart, c- chart and u- chart)

4.5.3 Control Chart for Variables

These charts are plotted the quality characteristics that are measurable on a numerical scale. Various types are discussed below.

- $\overline{X}$ -R Control Charts: The $\overline{X}$ -R Shewhart control charts are widely used to monitor the process mean and variability. $\overline{X}$ -R charts assume that individual responses be continuous and normally distributed. In education field, $\overline{X}$ -R chart can be used to determine the trends and differences overtimes or between students of various disciplines on the basis of scores secured in examinations. These charts are used for small sample sizes.
- $\overline{X}$ -S Control Charts: The $\overline{X}$ -R Shewhart control charts are widely used to monitor the process mean and variability. $\overline{X}$ -R charts assume that individual responses be continuous and normally distributed. In education field, $\overline{X}$ -R chart can be used to determine the trends and differences overtimes or between students of various disciplines on the basis of scores secured in examinations. These charts are used for large sample sizes.

Mean value: $\overline{X} = \frac{(X_1 + X_2 + ... + X_K)}{K}$

Standard deviation: $S = \sqrt{\frac{\sum_{i=1}^{K}(\overline{X} - X_i)^2}{K-1}}$

4.5.4 Control Charts for Attributes

An attribute is a quality characteristic for which a numerical value is not specified. It is measured on a nominal scale. A quality characteristic that does not meet certain standards is said to be nonconformity (defect). A product with one or more nonconformities, such that it is unable to meet the intended standards and is unable to function as required, is a nonconforming item (or defective). Some of the charts have been discussed below.

- p- Chart: "p" chart is a fraction nonconforming chart for attribute. This chart can be used to evaluate the effectiveness of class- teaching. It can identify statistically significant differences in instructors teaching abilities. For example, in engineering education, if a survey question requires a "yes-no" or "satisfied –dissatisfied" responses, the "p" chart can be used to monitor the proportion of those individuals responding "yes" or "no".

$$\overline{P} = \frac{nP_1 + nP_2 + \ldots + nP_K}{n_1 + n_2 + \ldots + n_K}$$

$$n = \frac{n_1 + n_2 + \ldots + n_k}{K}$$

$$\sigma = \sqrt{\frac{\overline{P}(1-\overline{P})}{n}}$$

The Central Line, Upper Control Limit and Lower Control Limit of the p chart are set as follow:

$$CL = \overline{P}$$
$$UCL = \overline{P} + 3\sigma$$
$$LCL = \overline{P} - 3\sigma$$

- np - Chart : it is known as chart for number of nonconforming. In this we can count the number of nonconforming items in the samples and use it for the control chart. The number of nonconforming items in the sample is assumed to be given by a binomial distribution. These charts are used only for constant sample sizes.

$$CL = n\overline{p}$$
$$UCL = n\overline{p} + 3 \times \left[\sqrt{n\overline{p}}\left(1-\overline{p}\right)\right]$$
$$LCL = n\overline{p} - 3 \times \left|\sqrt{n\overline{p}}\left(1-\overline{p}\right)\right|$$

- c- Chart: it is known as chart for the number of nonconformities. The occurrence of nonconformities is assumed to follow a Poisson distribution.

$$CL = \overline{c}$$
$$UCL = \overline{c} + 3 \times \left|\sqrt{\overline{c}}\right|$$
$$LCL = \overline{c} + 3 \times \left|\sqrt{\overline{c}}\right|$$

A case study was performed to check the state of quality in the education system of Engineering Institute (NCR). The study was done to find out the competency of technical education methods whether they are fulfilling their requirements regarding the output (technical up gradation of students, placement competency, etc.) are fulfilled or not.

In the instance, there are 10 different streams. All the streams were monitored on the basis of the result of second semester examination of all the streams held in MAY/JUNE-2009. If all the teaching processes have to be in control then the stream's average marks and the fail rate should be in control.

The class's average mark and fail rate reflect quality of education. According to different distribution characteristics of average marks and fail rates, $\overline{X}$ -S chart is adopted to monitor and analyze the average marks; p-chart is adopted to monitor and analyze the fail rates. If any abnormal is found, it's necessary to find the causes for the existed problems, then to give suggestions and solutions.

Collected data of 10 streams second semester examination marks is shown in Table 19.

Table 4.18 Statistical Data for 10 Streams

Stream	No. of Students in each Stream (1)	Average % Marks (2)	No. of Students Failed (3)	Fail Rate (4) = (3/1)
Mechanical (ME)	119	62.50	34	28.60
Production & Industrial(PE)	31	61.10	12	38.70
Environmental (EN)	20	68.80	2	10
Computer (CO)	90	66.20	16	17.80
Electronics & Communication (EC)	122	67.40	16	13.20
Electrical (EE)	90	68.60	12	13.30
Biotechnology (BT)	20	65.20	7	35.00
Civil (CE)	71	65.50	9	12.70
Information Technology (IT)	60	67.60	10	16.70

Polymer Science (PS)	37	63.10	11	29.70

Total No. of students (n) = 660, No. of Streams (K) = 10

4.5.5 $\overline{X}$ -S Control Chart

To draw a $\overline{X}$ -S chart, related parameters could be calculated according to Table 19.

Mean value: $\overline{X} = \dfrac{(X_1 + X_2 + ... + X_K)}{K}$

Standard deviation: $S = \sqrt{\dfrac{\sum_{i=1}^{K}(\overline{X} - X_i)^2}{K-1}}$

The values of the mean ($\overline{X}$**)** and standard deviation (S) are calculated using the above formulas.

Mean Value ($\overline{X}$) = 65.64%
Standard deviation (S) = 2.58

Centre Line (CL) = $\overline{X}$ = 65.64%

Upper Control Limit (UCL) = $\overline{X}$ + 2.66 S = 65.64 + 3 * 2.58 = 72.50

Lower Control Limit (LCL) = $\overline{X}$ **-** 2.66 S = 65.64 – 3 * 2.58 = 60.90

A $\overline{X}$ ***-S*** chart is drawn using X1, X2, … , XK, CL, UCL and LCL, if a point is located beyond the area between UCL and LCL, so this point should be determined to be out of control, according to 3 σ standard, the reliability of right judging is 99.73%. If a point is located up above the UCL, the average mark of this given class is abnormally higher than the mean value; if a point is located down below the LCL, the average mark of this given class is abnormally lower than the mean value hence, these two cases need to be carefully investigated, the causes need to be studied.

The drawn $\overline{X}$ **-S** chart is shown in Figure 4.4.

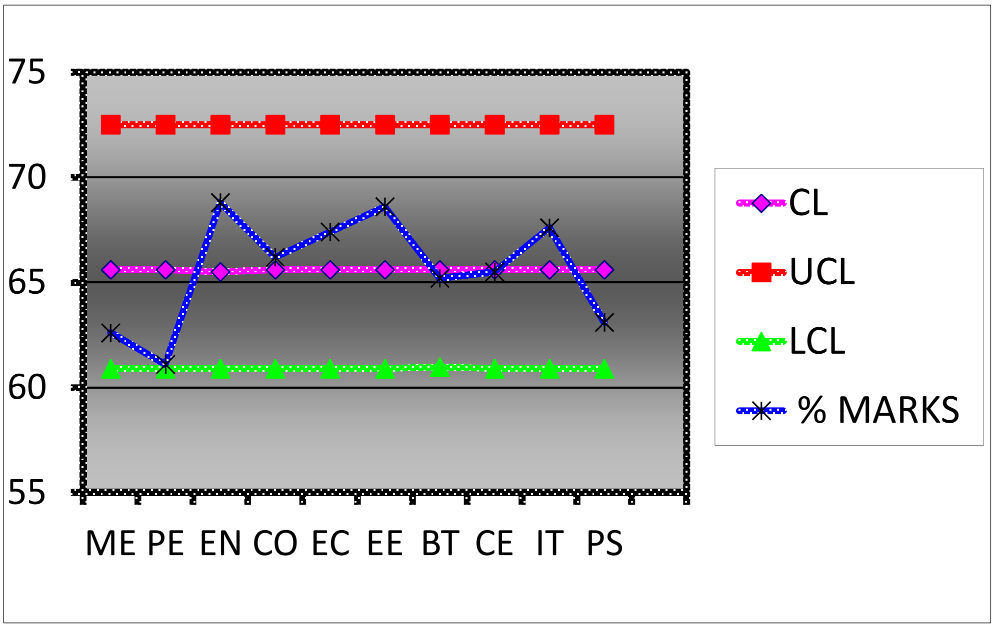


Figure 4.4 $\overline{X}$ -S Control Chart for Average % Marks

Chart shows that the process is statistically under control for all the streams except the point No. 2 i.e. Production and Industrial Engineering (PE) stream which is located very close to the normal area for abnormal low average % marks i.e. LCL, hence there is a need to further investigate. This shows that there some problem in PE and hence certain measures have to be taken in order to improve the quality of PE.

4.5.6 p- Chart

If "Pass" and "Fail" are used to present student's examination mark, the data of classes' fail number is follow the binomial distribution, because number of students in classes are different, so the p- chart is chosen to monitor the fail rates.

Assuming there are K classes, the numbers of students for classes are n_1, n_2, …, n_k, and its fail number of students is nP_1, nP_2, …, nP_k, so that the total average fail rate (mean value) $\overline{P}$, average class number of students "n" and standard deviation could be calculated as follow:

$$\overline{P} = \frac{nP_1 + nP_2 + ... + nP_K}{n_1 + n_2 + ... + n_K}$$

$$n = \frac{n_1 + n_2 + ... + n_k}{K}$$

$$\sigma = \sqrt{\frac{\overline{P}(1-\overline{P})}{n}}$$

The values of the mean ($\overline{P}$) and standard deviation (σ) are calculated using the above formulas.

Mean Fail Rate ($\overline{P}$) = ∑ Fail Rate / 10 = 2.18 = 0.22

Standard Deviation (σ) = 0.051

Centre Line (CL) = $\overline{P}$ = 0.22

Upper Control Limit (UCL) = $\overline{P}$ + 3 σ = 0.22 + 3 * 0.051 = 0.37

Lower Control Limit (LCL) = $\overline{P}$ - 3 σ = 0.22 - 3 * 0.051 = 0.07

The drawn p-chart is shown in Figure 4.5.

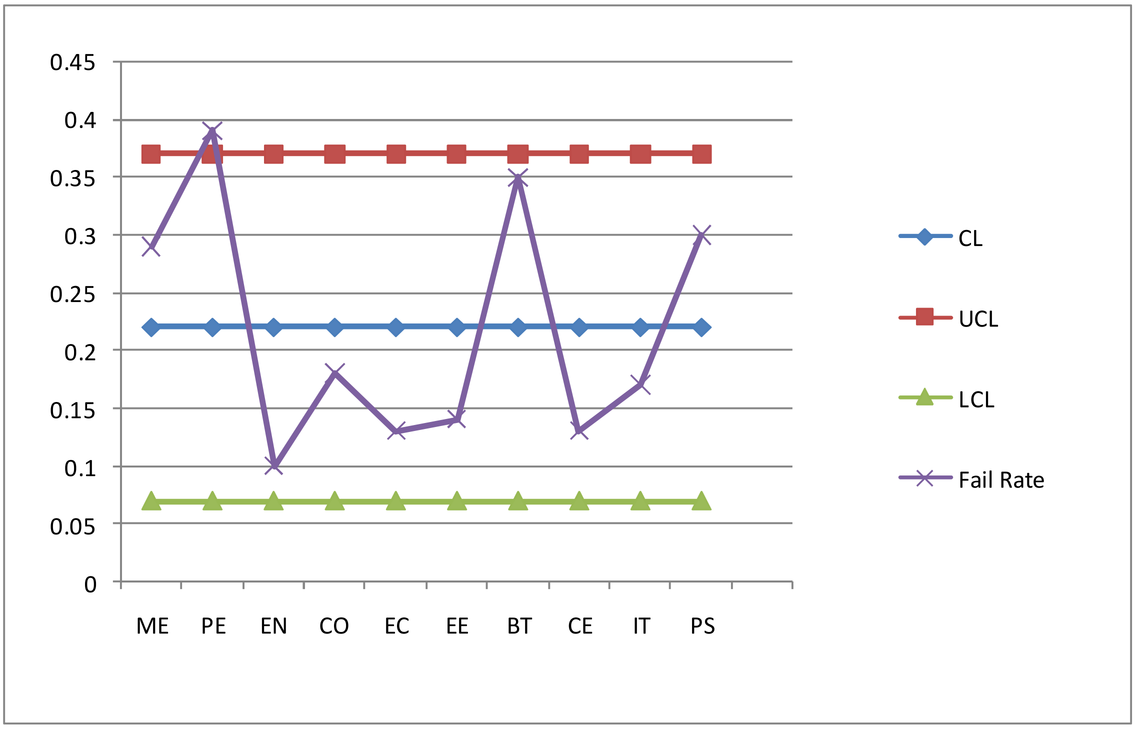


Figure 4.5 p- Control Chart for Fail Rate

Chart shows that the process is statistically under control for all the streams except the point No. 2 i.e. Production and Industrial Engineering (PE) stream which is located outside the normal area for abnormal high fail rate i.e. UCL, hence there is a need to further investigate. This shows that there some problem in PE and hence certain measures have to be taken in order to improve the quality of PE.

4.5.7 Conclusions

Statistical process control (SPC) is applied to analyze the results of second semester examination of all the streams held in MAY/JUNE-2009. The technique proves to be effective and the SPC control chart shows the problems occurring in the streams. The study shows that there is a need to investigate the Production Engineering stream as in both the control charts their values are crossing the control limits (LCL, UCL). There is a need to identify the causes of the problems viz. qualifications and merits of the students entry, faculty expertise, adequacy of subject teacher, effective classroom management, faculty's rapport with student and student's understanding level so that the quality of the technical education system can be improved.

4.6 Case Study No. 5-Application of Fuzzy-Analytical Hierarchy Process Approach (AHP) for assessing Quality in Technical Education*

4.6.1 Introduction

4.6.1.1 Analytic hierarchy process (AHP)

The AHP was developed in the 1970s by Saaty (56) of the Wharton School of Business (Saaty, 1977, 1980) (56). It is a systematic and scientific MCDM method and is able to solve complicated and subjective decision making problems. AHP can be used to solve problems under uncertain circumstances with multiple criteria. In AHP, multiple paired comparisons are based on a standardized evaluation scheme (1=equal importance; 3=weak importance; 5=strong importance; 7=demonstrated importance; 9=absolute importance). The AHP uses pair-wise comparisons to compare n elements under given conditions and then converts vague verbal response into a 9-point linguistic scale. The results of the pair-wise comparisons can be used to construct a judgment matrix, and then the normalized Eigen vector corresponding to the maximum Eigen-value (l-max) can be calculated. The consistency of the matrix can be determined by checking the consistency ratio (CR). A CR that is less than 0.1 indicates a consistent judgment (Saaty, 1980).

4.6.1.2 Fuzzy AHP

Many fuzzy AHP methods have been proposed by various authors. These methods are systematic and useful approaches to the alternative selection and gives justification to the problem by using the concepts of fuzzy set theory and hierarchical structure analysis. Decision makers have experienced that it is more confident and easy to give interval judgments than fixed value judgments. This is due to the fuzzy nature of the comparison process. The Fuzzy-AHP methodology extends Saaty's AHP by_combining it with the fuzzy set theory. In the Fuzzy-AHP, fuzzy ratio scales are used to indicate the relative strength of the factors in the corresponding criteria. Therefore, a fuzzy judgment matrix can be constructed. The final scores of alternatives are also represented by fuzzy numbers. The optimum alternative is obtained by ranking the fuzzy numbers using special algebra operators.

The next three steps can summarize the procedure of applying Fuzzy-AHP:

(i) Construct a hierarchical structure for the problem to be solved.

(ii) Establish the fuzzy judgment matrix and a fuzzy weight vector.

(iii) Rank all alternatives and select the optimal one.

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In this methodology, all elements in the judgment matrix and weight vectors are represented by triangular fuzzy numbers. Using fuzzy numbers to indicate the relative contribution or impact of each alternative on a criterion, a fuzzy judgment vector is then obtained for each criterion. The fuzzy judgment matrix A is built with all the fuzzy judgment vectors. The weight vector W is used to represent the decision maker's opinion of the relative importance of each criterion during the decision process. A fuzzy number-x expresses the meaning 'about x'. Each membership function is defined by three parameters of the symmetric triangular fuzzy number, (l, m, r), left, middle and right points of the range over which the function is defined. Fuzzy membership function and the definition of a fuzzy number are shown in Fig. 1. When the decision-maker faces a complex and uncertain problem and expresses his/her comparison judgments as uncertain ratios, such as 'about two times more important', 'between two and four times less important', etc., the standard AHP steps, and specially, Eigen-value prioritization approach, cannot be considered as straightforward procedures. Indeed, the assessment of local priorities, based on pair wise comparisons needs some prioritization method to be applied.

4.6.2 Literature review

The earliest work in fuzzy AHP started from 1983. Laarhoven and Pedrycz (60) compared fuzzy ratios described by triangular membership functions. Chang[6] introduced a new approach for handling fuzzy AHP, with the use of triangular fuzzy numbers for pairwise comparison scale of fuzzy AHP, with the use of the extent analysis method for the synthetic extent values of the pairwise comparisons.

Kahraman et al. (61) employed a fuzzy objective and subjective method and obtained the weights from AHP and then made a fuzzy weighted evaluation. Deng (62) presented a fuzzy approach for tackling qualitative multi-criteria analysis problems in a simple and easier way. Lee et al. (63) review the basic ideas behind the AHP.

Based on the ideas, they introduced the concept of comparison interval and proposed a methodology based on stochastic optimization to achieve global consistency and to accommodate the fuzzy nature of the comparison process. Cheng et al (64). proposed a new method for evaluating weapon systems by AHP which was based on linguistic variable weight. Zhu et al. (65) carried out a discussion on extent analysis method and applications of fuzzy AHP.

Kahraman et al. (66), employed fuzzy AHP technique for comparison of catering service companies. He carried out the process on certain main and sub attributes which were proposed by experts that are required in a catering firm. He then proposed the best firm out of the three firms presented and also concluded that fuzzy AHP can be effectively applied in the given field.

4.6.3 Methodology

In the following, a brief description of the extent analysis method on fuzzy AHP is discussed and then the application of the method in the education sector is discussed.

Let X = {x_1, x_2… x_n} be an object set, and U = {u_1, u_2… u_m} be a goal set. According to the method of Chang's (67) extent analysis, each object is taken and extent analysis for each goal, gi, is performed, respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs (66, 67):

$$M_{gi}^{1}, M_{gi}^{2}, \ldots\ldots, M_{gi}^{m}, i = 1, 2, \ldots., n$$

Where, all the M^j_{gi} (j =1, 2…..m) are TFNs.

The steps of Chang's extent analysis can be given as in the following (66, 67):

Step 1: The value of fuzzy synthetic extent with respect to the i^{th} object is defined as,

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$$

To obtain $\sum_{j=1}^{m} M_{gi}^{j}$ we perform the fuzzy addition operation of m extent analysis (66, 67) values for a particular matrix such that,

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right)$$

And to obtain, $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$ we have to perform the fuzzy addition operation of M^j_{gi} (j =1, 2…..m) values such that;

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_j, \sum_{i=1}^{n} m_j, \sum_{i=1}^{n} u_j \right)$$

The inverse of the vector in the above equation can be written as,

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right)$$

Step 2: The degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_l, u_1)$ is defined as (66, 67): $V(M_2 \geq M_1) = \sup_{y \geq x} \left[\min\left(\mu_{M_1}(x), \mu_{M_2}(y) \right) \right]$

and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = \operatorname{hgt}(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, & \text{if } m_2 \geq m_1, \\ 0, & \text{if } l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise}. \end{cases}$$

To compare M_1 and M_2, we need both the values of $V(M_2 \geq M_1)$ and. $V(M_1 \geq M_2)$

Step 3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i (i=1, 2,….., k) can be defined by (67),

$$V(M \geq M_1, M_2, \ldots, M_k)$$
$$= V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } \ldots \text{ and } (M \geq M_k)]$$
$$= \min V(M \geq M_i),\ i = 1, 2, 3, \ldots, k.$$

Assume that

$$d'(A_i) = \min V(S_i \geq S_k).$$

for, k=1,2,…..,n and k≠ i . Now the weight vector can be given by the following formulae,

$$W' = (d'(A_1), d'(A_2), \ldots\ldots, d'(A_n))^T$$

Where, A_i (i=1, 2, 3…... n) are n elements.

Step 4: Via normalization, the normalized weight vectors are given as,

$$W = (d(A_1), d(A_2), \ldots\ldots, d(A_n))^T,$$

Where, "W" is a non- fuzzy number.

4.6.4 Research objectives

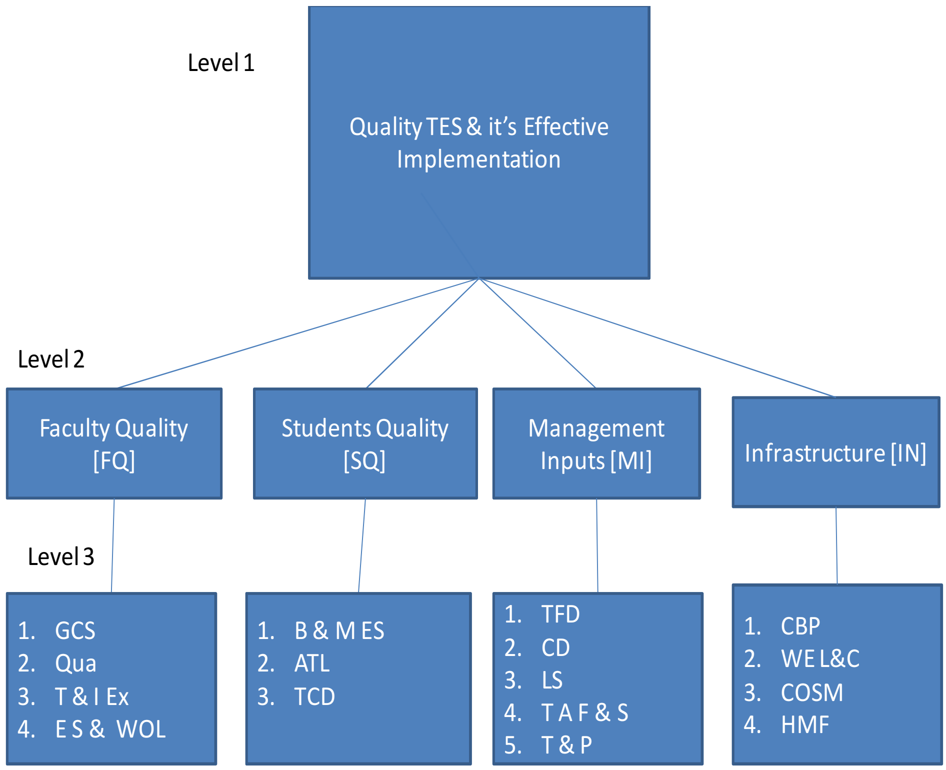
The objective of this study is to identify and rate the factors which are responsible for assessing the quality of technical education and thus help in monitoring, controlling and improving the quality of technical education at various levels. In this work a multi criterion decision making (MCDM) tool known as "**FUZZY AHP** has been used. Fuzzy AHP technique is used for finding out the weightage of the main and sub criterion attributes of technical education system. The factors taken in this research have been taken from various experts view and from the previous research and literature review mentioned earlier.

The research allows us to decide which attributes are most and least important and the ranking of the attributes taken.

Hence in this study the major objective which are as under, have been successfully implemented.

- To develop an instrument for measuring quality in the technical education sector
- To determine the rank of the attributes capable of affecting quality of a TES.
- To test the adequacy of Fuzzy AHP for modeling the Attributes of quality in education.

Hierarchy Model for Quality in Technical Education



The fig. above shows a hierarchy model for quality in technical education. At level 1 is the ultimate goal i.e. to get a quality TES. At the level 2 main attributes of TES are present whose effective implementation and proper running results in a quality TES. At level 3 the Sub attributes of the main attributes are given whose proper functioning in turn effect the effectiveness of the main attributes. It shows the attributes that have been analyzed in the paper. First the main attributes are analyzed and then their sub attributes are prioritized using fuzzy AHP. In the end all the attributes are ranked according to the priority weights obtained and important attributes are recognized.

4.6.5 Data Collection

Data for the research was collected in the form of the questionnaire. The questionnaire was distributed to a large number of students, faculty, recruiters, alumni and people working in the industries. The questionnaire consisted of the above mentioned attributes (main & sub). The questionnaire was based on pairwise comparison of the attributes. The format of the questionnaire is shown in appendix.

4.6.6 Data Analyses and Calculations

Table 4.19 shows the pairwise comparison matrix for the main and sub attributes. It was constructed with the responses obtained from the comparison questionnaire. Now by using the formulas mentioned under **"Step 4"** the values were calculated for all the variables in order to get the desired values of priority vectors and finally **"W"** which gives us the global weight of the attributes.

4.6.7 Quality management and assurance in technical education

This International Standard specifies requirements for a quality management system where an institute:

(a) Needs to motivate its ability to consistently provide knowledge to students that meets the international standards and are able to provide good quality service to the nation and society to grow.

(b) Aims to quality satisfaction through effective application of the system, including processes for continual improvement of the system and the assurance of conformity to students and top authority.

Some of the important main attributes of a TES are:

- Faculty Quality (FQ)
- Students Quality (SQ)
- Management Inputs (MI)
- Infrastructure (IN)

These are main attributes whose efficient working and good performance results into a quality TES. Quality in education can be assessed and improved with high accuracy by monitoring the above attributes. There are certain attributes that comes under the above main attributes. They are:

- **Faculty Quality:** various attributes are Faculty expertise, Adequacy of subject teacher, Effective classroom management, Teaching quality and productivity, Amount of teaching and industrial experience (T&I Ex), Good communication skills (GCS), Qualifications of Faculty (Qua), Expertise in Subject and Well-Organised Lectures (ES & WOL) etc.
- **Students Quality:** attributes are Background and merits of the entering students (B & MES), Fraction engaging in undergraduate research, Fraction completing graduation as per the university or govt. norms, Time taken to complete the degree (TLD), Attitude towards learning (ATL)

- **Management Inputs:** The lack of adequate inputs by the management and non provision of qualified, well paid and professional faculty adversely affects the quality of technical education. Some of the major points to be considered by the management are as follows; Training for Faculty Development (TFD), Timely Assessment of Faculty and Students (T A F&S), Library Standards (LS), Adaptability to modern techniques. Curriculum Design (upgradation of modern techniques) (CD), Opportunities for campus training and placement (T&P), Transparency of official procedure, norms and rules, etc.
- **Infrastructure in an Institution:** attributes are; provide Well-equipped laboratories with modern facilities (WO L&C), Cleanliness, orderliness, systematic and methodical (COSM) of the institute, College building and premises (CBP), Hostel and Mess facility (HMF), etc.

Table 4.19 Main Attribute pair wise Comparison Matrix

Main Attributes	FQ	SQ	MI	IF
FQ	(1,1,1)	(7/2,4,9/2)	(3/2,2,5/2)	(2/3,1,3/2)
SQ	(2/9,1/4,2/7)	(1,1,1)	(2/3,1/2,2/3)	(5/2,3,7/2)
MI	(2/5,1/2,2/3)	(3/2,2,5/2)	(1,1,1)	(5/2,3,7/2)
IF	(2/3,1,3/2)	(2/7,1/3,2/5)	(2/7,1/3,2/5)	(1,1,1)

From table 4.19, S_{FQ}= (6.67, 8.00, 9.50) $\otimes\left[\frac{1}{25.93},\frac{1}{21.93},\frac{1}{18.44}\right]$= (0.26, 0.36, 0.52), S_{SQ}= (4.12, 4.75, 5.46) $\otimes\left[\frac{1}{25.93},\frac{1}{21.93},\frac{1}{18.44}\right]$= (0.16, 0.22, 0.30), S_{MI}= (5.40, 6.50, 7.70)$\otimes\left[\frac{1}{25.93},\frac{1}{21.93},\frac{1}{18.44}\right]$= (0.21, 0.30, 0.42) and S_{IN}= (2.25, 2.48, 3.30) $\otimes\left[\frac{1}{25.93},\frac{1}{21.93},\frac{1}{18.44}\right]$= (0.09, 0.12, 0.18) are obtained. Using these values the vectors obtained are as follows; V ($S_{FQ}\geq S_{SQ}$) = 1, V ($S_{FQ}\geq S_{MI}$) = 1, V ($S_{FQ}\geq S_{IN}$) = 1; V ($S_{SQ}\geq S_{FQ}$) = 0.22, V ($S_{SQ}\geq S_{MI}$) = 0.09, V ($S_{SQ}\geq S_{IN}$) = 1; V ($S_{MI}\geq S_{FQ}$) = 0.73, V ($S_{MI}\geq S_{SQ}$) = 1, V ($S_{MI}\geq S_{IN}$) = 1; V ($S_{IN}\geq S_{FQ}$) = 0.15, V ($S_{IN}\geq S_{SQ}$) = 0.25, V ($S_{IN}\geq S_{MI}$) = 0.18 are obtained. Hence the weight vector from table can be calculated as $W_{MA} = (0.48,0.11,0.35,0.06)^T$

Similarly the sub attributes for each of the main attributes are compared and the vectors are calculated as follow

Table 4.20 Sub Attribute of Faculty Quality pair wise Comparison Matrix

Faculty Quality Sub- Attributes	GCS	Qua	T&I Ex	E S&WOL
GCS	(1,1,1)	(1,1,1)	(5/2,3,7/2)	(3/2,2,5/2)
Qua	(1,1,1)	(1,1,1)	(7/2,4,9/2)	(3/2,2,5/2)
T&I Ex	(2/7,1/3,2/5)	(2/9,1/4,2/7)	(1,1,1)	(2/3,3,3/2)
E S& WOL	(2/5,1/2,2/3)	(2/3,1/2,2/5)	(2/3,1,3/2)	(1,1,1)

From table 4.20 we get, S_{GCS}= (0.25, 0.34, 0.45), S_{Qua}= (0.30, 0.39, 0.50), $S_{T\&I\ Ex}$ = (0.10, 0.13, 0.18) and $S_{E\&S\ WOL}$ = (0.12, 0.15, 0.20); V ($S_{GCS} \geq S_{Qua}$) = 0.75, V ($S_{GCS} \geq S_{T\&I\ Ex}$) = 1, V ($S_{GCS} \geq S_{E\&S\ WOL}$) = 1; V ($S_{Qua} \geq S_{GCS}$) = 1, V ($S_{Qua} \geq S_{T\&I\ Ex}$) = 1,V ($S_{Qua} \geq S_{E\&S\ WOL}$) = 1; V ($S_{T\&I\ Ex} \geq S_{GCS}$) = 0.43, V ($S_{T\&I\ Ex} \geq S_{Qua}$) = 0.28, V ($S_{T\&I\ Ex} \geq S_{E\&S\ WOL}$) = 0.60; V ($S_{E\&S\ WOL} \geq S_{GCS}$) = 0.22, V ($S_{E\&S\ WOL} \geq S_{Qua}$) = 0.15, V ($S_{E\&S\ WOL} \geq S_{T\&I\ Ex}$) = 1 are obtained. Hence the weight vector from table 4.20 can be calculated as $W_{FQSA} = (0.35,0.46,0.13,0.06)^T$.

Table 4.21 Sub Attribute of Students Quality pairwise Comparison Matrix

Students Quality Sub- Attributes	B & MES	ATL	TCD
B & MES	(1,1,1)	(3/2,2,5/2)	(2/3,1,3/2)
ATL	(2/5,1/2,2/3)	(1,1,1)	(3/2,2,5/2)
TCD	(2/3,1,3/2)	(2/5,1/2,2/3)	(1,1,1)

From table 4.21 we get, $S_{B\&M\ ES}$= (0.26, 0.40, 0.61), S_{ATL}= (0.24, 0.35, 0.51) and S_{TCD} = (0.17, 0.25, 0.39); V ($S_{B\&M\ ES} \geq S_{ATL}$) = 1, V ($S_{B\&M\ ES} \geq S_{TCD}$) = 1; V ($S_{ATL} \geq S_{B\&M\ ES}$) =

0.84; V ($S_{ATL} \geq S_{TCD}$) = 1, V ($S_{TCD} \geq S_{B\&MES}$) = 0.47, V ($S_{TCD} \geq S_{ATL}$) = 0.61; are obtained. Hence the weight vector from table 3 can be calculated as

$$W_{SQSA} = (0.43, 0.37, 0.20)^T$$

Table 4.22 Sub Attribute of Infrastructure pairwise Comparison Matrix

Management Inputs Sub- Factors	TFD	CD	LS	TA F&S	T&P
TFD	(1,1,1)	(2/9,1/4,2/7)	(3/2,2,5/2)	(1,1,1)	(2/3,1,3/2)
CD	(7/2,4,9/2)	(1,1,1)	(5/2,3,7/2)	(3/2,2,5/2)	(1,1,1)
LS	(2/5,1/2,2/3)	(2/7,1/3,2/5)	(1,1,1)	(2/5,1/2,2/3)	(2/7,1/3,2/5)
TA F&S	(1,1,1)	(2/5,1/2,2/3)	(3/2,2,5/2)	(1,1,1)	(1,1,1)
T&P	(2/3,1,3/2)	(1,1,1)	(5/2,3,7/2)	(1,1,1)	(1,1,1)

From table 4.22 we get the weight vector as $W_{INSA} = (0.17, 0.68, 0.09, 0.06)^T$

Table 4.23 Sub Attribute of Management Inputs pair wise Comparison Matrix

Infrastructure Sub- Factors	CBP	WE LC	COSM	HMF
CBP	(1,1,1)	(2/9,1/4,2/7)	(3/2,2,5/2)	(3/2,2,5/2)
WE LC	(7/2,4,9/2)	(1,1,1)	(5/2,3,7/2)	(3/2,2,5/2)
COSM	(2/5,1/2,2/3)	(2/7,1/3,2/5)	(1,1,1)	(1,1,1)
HMF	(2/5,1/2,2/3)	(2/5,1/2,2/3)	(1,1,1)	(1,1,1)

From table 4.23 we get the weight vector as $W_{MISA} = (0.11, 0.47, 0.07, 0.18, 0.17)^T$

Table 4.24 Summary of Global Priority Weights of Main Attributes and Sub Attributes for Assessing Quality in Technical Education

Ranking of Main and Sub Attributes	Global Priority Weights
Faculty Quality (FQ)	**0.4800**
❖ Good Communication Skills (GCS)	0.1632
❖ Qualification of Faculty (Qua)	0.2208
❖ Teaching & Industrial Experience (T&I Ex)	0.0624
❖ Expertise in Subject and Well Organised Lectures (ES &WOL)	0.0336
Students Quality (SQ)	**0.1100**
❖ Background & Merit of Entering Students (B&M ES)	0.0473
❖ Attitude Towards Learning (ATL)	0.0407
❖ Time Taken to Complete Degree (TCD)	0.0220
Management Inputs (MI)	**0.3500**
❖ Training for Faculty Development (TFD)	0.0385
❖ Curriculum Design (CD)	0.1645
❖ Library Standards (LS)	0.0245
❖ Timely Assessment of Faculty & Students (TA F& S)	0.0630
❖ Training & Placement (T&P)	0.0595
Infrastructure (IN)	**0.0600**
❖ College Building & Premises (C B&P)	0.0102
❖ Well Equipped Labs and Classrooms (WE L&C)	0.0408
❖ Cleanliness, Orderliness, Systematic and Methodical (COSM)	0.0054
❖ Hostel and Mess Facility (HMF)	0.0036

4.6.8 Conclusions

The major contribution of this study is to provide a systematic integrated approach for modeling the various attributes of a quality TES. Education is a service sector hence its quality is not dependent on one or two people. The stakeholders in an education sector ranges from students, faculty, recruiters, etc. hence an educational set up has the responsibility to satisfy everyone's needs. This often results in difficulties for implementing quality control and improvement programmes and policy planning. Therefore, it is advisable to identify the minimum number of important attributes that suit all the stakeholders before implementing any quality improvement programme. A survey-based model, has been specially developed to suit a technical education system. A literature review has been done and certain important attributes of a quality TES are determined. Some of the attributes are taken from experts also. Then a questionnaire was constructed and a review was taken from a large number of students, faculty, etc. and then the fuzzy AHP comparison matrices were made and by using the Fuzzy AHP along with extent analysis method global priority weights for each attributes were calculated. The analysis concluded that the following are the most important attributes of quality TES and should be given utmost importance. They are: (global priority weight >0.04) Qualification of Faculty (Qua), Curriculum Design (CD), Good Communication Skills (GCS), Timely Assessment of Faculty & Students (TA F& S), Teaching & Industrial Experience (T&I Ex), Training & Placement (T&P), Background & Merit of Entering Students (B&M ES), Well Equipped Labs and Classrooms (WE L&C) and Attitude Towards Learning (ATL).

The results showed that the qualification of the faculty is one of the most important attribute; hence the TES should employ a highly qualified faculty in order to achieve quality in technical education. The present technical education system throughout the country urgently needs to design the curriculum on the basis of new trends, rapid technological growth, etc. there is also a great need to modernize the laboratories and classrooms with the latest technology so that students would be aware of the recent developments around the world. Along with faculty; students, management and the infrastructure also plays a vital role in obtaining quality in technical education. Hence all these main attributes with some of their important sub attributes should be there in a TES to achieve quality in technical education.

4.7 Case Study No. 6-Application of Fuzzy AHP for Multi-Attribute Comparison of Technical Institutions/Colleges: An expert Approach*

4.7.1 Introduction

In order to demonstrate the use of fuzzy AHP methodology in comparison of technical institutions/colleges, a case study has been discussed in this chapter. In this 3 technical institutions/colleges namely A, B and C located in Delhi/NCR region were selected. All the 3 institutions/colleges are among the reputed colleges of the NCR region. They have been providing quality education for more than 10 years. They are into all kinds of engineering courses and are known for their excellence. We considered these institutions due to their market reputation for the analysis. For confidentiality we will name those institutions as A, B and C.

Then, the selection phase was arranged. The panel of expert was instructed about the fundamentals of approximate reasoning, fuzzy logic, and the AHP methodology to be adopted. Specifically, the panel acknowledge about the efficacy of the results provided by AHP. Then a structured "request for information" was prepared and sent out to the highly qualified professionals of academia and also a feedback was taken from experts from the industries. The project team agreed that the selection criteria to be used in the "request for information" were those illustrated in the case study discussed in the earlier chapter. The institutes were compared on the basis of the 4 main attributes i.e. Faculty Quality (FQ), Students Quality (SQ), Management Inputs (MI) and Infrastructure (IN).

The goal of the research is to select the best institute among the 4 institutes taken for analysis on the basis of the main attributes and the priority weights obtained in the previous chapter.

The panel was separately asked to express verbal opinions about institute performance for each selection criterion. Then aggregate of weight and criteria rating is done and no institute is considered better than other because every provider has some strength and weakness.

** Part of this case study is published in the International Journal of Applied Engineering Research, Vol. 5, No. 21-22, 2010 PP -3455-3467 (ISSN 0973-4562)*

The hierarchy model for the comparison has been shown below in fig. 4.6.

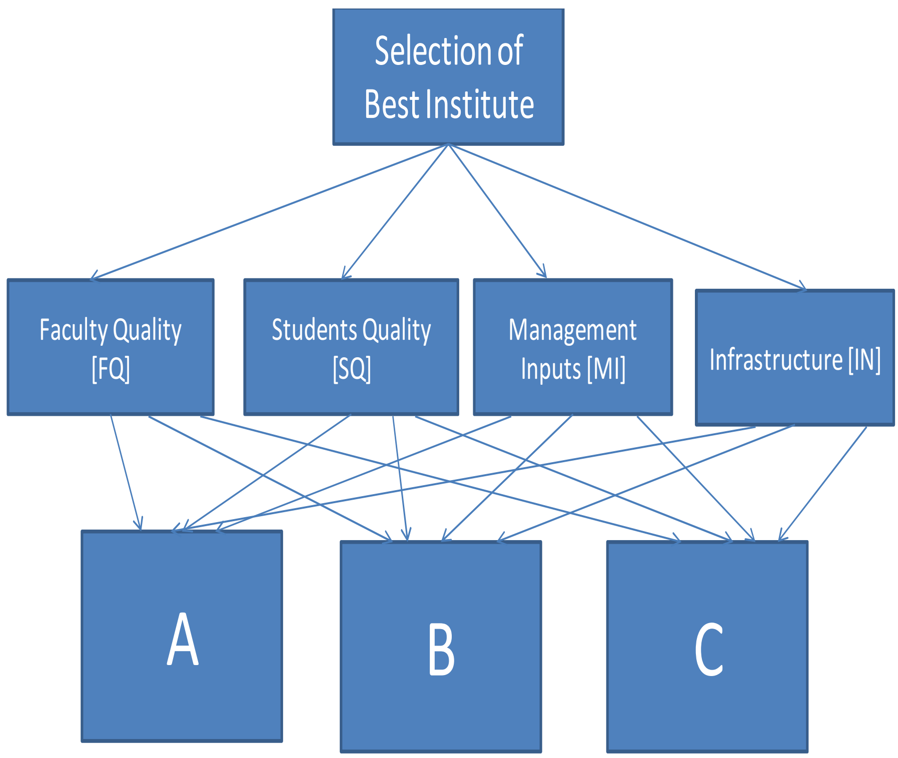


Figure 4.6 Hierarchy Model for comparison of Engineering Institutions

4.7.2 Data Collection and Analysis

Data was collected in the form of pairwise comparison matrix in fuzzy environment and then fuzzy AHP methodology using extent analysis was used for the analysis purpose. The description of the methodology used has been discussed in the previous chapters.

Table 4.25 Evaluation of technical institutions w.r.t. Faculty Quality (FQ)

Faculty Quality (FQ)	A	B	C
A	(1,1,1)	(2/3,1,3/2)	(1,1,1)
B	(2/3,1,3/2)	(1,1,1)	(2/9,1/4,2/7)
C	(1,1,1)	(7/2,4,9/2)	(1,1,1)

The weight vector from the table 4.25 is calculated as $W_{FQ}= (0.27, 0.18, 0.55)^T$.

Table 4.26 Evaluation of technical institutions w. r. t. Students Quality (SQ)

Students Quality (SQ)	A	B	C
A	(1,1,1)	(3/2,2,5/2)	(2/7,1/3,2/5)
B	(2/5,1/2,2/3)	(1,1,1)	(7/2,4,9/2)
C	(5/2,3,7/2)	(2/9,1/4,2/7)	(1,1,1)

The weight vector from the table 4.26 is calculated as $W_{SQ}= (0.05, 0.64, 0.31)^T$.

Table 4.27 Evaluation of technical institutions w. r. t. Management Inputs (MI)

Management Inputs (MI)	A	B	C
A	(1,1,1)	(3/2,2,5/2)	(2/3,1,3/2)
B	(2/5,1/2,2/3)	(1,1,1)	(3/2,2,5/2)
C	(2/3,1,3/2)	(2/5,1/2,2/3)	(1,1,1)

The weight vector from the table 4.27 is calculated as $W_{MI}= (0.43, 0.37, 0.20)^T$.

Table 4.28 Evaluation of technical institutions w. r. t. Infrastructure (IN)

Infrastructure (IN)	A	B	C
A	(1,1,1)	(3/2,2,5/2)	(3/2,2,5/2)
B	(2/5,1/2,2/3)	(1,1,1)	(2/3,1,3/2)
C	(2/5,1/2,2/3)	(2/3,1,3/2)	(1,1,1)

The weight vector from the table 4.28 is calculated as $W_{IN}= (0.70, 0.15, 0.15)^T$.

Table 4.29 Summary of Priority weights for Evaluation of Technical Institutions w. r. t. Main Attributes of the goal

	FQ	SQ	MI	IN	
Weight / Alternative	0.48	0.11	0.35	0.06	Alternative Priority Weight
A	0.27	0.05	0.43	0.70	0.33
B	0.18	0.64	0.37	0.15	0.30
C	0.55	0.31	0.20	0.15	0.37

We can infer from the above analysis that all the 3 institutes are almost similar in all respects and institute C is the best one.

4.7.3 Conclusion

This study mainly elaborates the applications of the Fuzzy AHP methodology for comparison of various technical institutions. The main attributes which have been considered are as under:

(i) Faculty Quality(FQ)
(ii) Students Quality(SQ)
(iii) Management Inputs (MI)
(iv) Infrastructure (IN)

Hierarchy model has been developed for the comparison of different Technical Institution. Concluded priority weight are 0.33, 0.30 and 0.37.It is observed that though the quality level of the Institutes considered is quite close to one another but the Institute No. C is the best.

4.8 Case Study No. 7-Analysis of the variables for Quality Management in Technical Education using Interpretive Structural Modeling (ISM)*

4.8.1 Introduction

ISM i.e. Interpretive Structural Modeling is an interactive learning process. The method is interpretive in that the group's judgment decides whether and how items are related, it is structural in that, on the basis of the relationship, an overall structure is extracted from the complex set of items, and it is modeling in that the specific relationships and overall structure are portrayed in a diagraph model. ISM methodology helps to impose order and direction of relationships among elements of a system (Sage, 1977). It provides us a means by which order can be imposed on the complexity of such variables (Mandal and Deshmukh, 1994; Jharkharia and Shankar, 2005). However; the direct and indirect relationships between the factors describe the situation far more accurately than the individual factor taken in isolation. Therefore, ISM develops insights into collective understandings of these relationships. The application of ISM helps to reassess perceived priorities and improve their understanding of the linkages among key concerns. To determine the key factor for improvement in technical education on which focus must be given so as to improve the effectiveness of Technical education system's, technique i.e. ISM which is earlier used for supply chain management (SCM) is applied to present Technical education system. Various factors that are used are categorized as enablers and result. The enablers stand for variable that are required for improvement in Technical education system. While results are the outcome of good Technical education system implementation that highlights the variables on which controlling body should focus for improvement. In this technique variables are defined in terms of driving & dependence power. Those variables possessing higher driving power in ISM need to be taken care of on a priority basis because there are few other dependent items being affected by them.

4.8.2 Literature Review

ISM is a well established methodology for identifying relationships among specific variables which define a problem or an issue (sage, 1977) (81).In area of supply chain management this ISM methodology is applied which shows the inter relationships of the enablers, their driving power and dependency. Jharkharia S & Shankar R (2004) (82) applied this method for IT enablement of supply chain for modeling the enablers to understand mutual influences of these enablers and also to identify those enablers which support other enablers.

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In 2006, Faisal et. al. (83) applied ISM technique for supply chain risk management by understanding the dynamics between various enablers that help to mitigate risk in supply chain. This research provides hierarchy based model and the mutual relationship among the enablers of risk mitigation. This classification provides a useful tool to supply chain managers to differentiate between independent and dependent variables.

In 2007, Singh K. Rajesh et al. (84) applied ISM technique for modeling of critical success factors for implementation of AMTS (advanced manufacturing technology) and developed the structural relationship among different factors for successful implementation of AMTs. In 2007, Singh K. Rajesh et. al. (85) applied ISM technique for modeling of factors for improving competitiveness of small and medium enterprises management to take strategic decisions. This research has tried to define the levels of different competitiveness factors based on their driving and dependence power and their mutual relationships

In 2008, Charan P. et. al. (86) apply ISM technique for analysis of interactions among the variables of supply chain performance measurement system implementation which Top management should focus so as to improve the effectiveness and efficiency of supply chain. In 2009, Pandey V.C. & Garg Suresh (87) applied ISM technology for analysis of interaction among the enablers of agility in supply chain. This research identifies the key supply chain variables on which the practitioner should focus to make supply chain of manufacturing enterprises more effective. Further these variables are structured to determine their interactive behavior.

From above study it is found that this interpretive structural modeling is applied in the area of supply chain where relationship, ranking & dependency of various factor is determined using this technique. Since in the field of technical education again we have number of variables that affect the quality of technical education .so there we try to implement this technique for finding the ranking of variable that affecting the TES.

In this model, there are 13 important variables[2] under the enabler and result categories. In the proposed ISM, to identify important TES (Technical Education system) implementation variables and to establish mutual relationship expert opinion is conducted. These variables are already ranked using expert opinion and then used that rating as firing strength for fuzzy application. In this technique variables are prioritized using ISM. The methodology of ISM acts as a tool for identifying relationships among specific items. The analysis of variables of TES technical education using the ISM approach shows the interrelationships of the variables, and their driving power and dependence. The variables under consideration in this study have been identified from the literature review and the opinion of the experts.

The main objectives are:

- To identify and rank the variables for improvement.
- To establish the relationship among these identified variables using ISM.

The various steps involved in the ISM technique are:

(1) Identification of elements, which are relevant to the problem or issues, this could be done by literature review or any group problem solving technique.

(2) Establishing a contextual relationship between elements with respect to which pairs of elements will be examined.

(3) Developing a structural self-interaction matrix (SSIM) of elements, which indicates pair-wise relationship between elements of the system?

(4) Developing a reachability matrix from the SSIM, and checking the matrix for transitivity. Transitivity of the contextual relation is a basic assumption in ISM which states that if element A is related to B and B is related to C, then A will be necessarily related to C.

(5) Partitioning of reachability matrix into different levels.

(6) Based on the relationships given above in the reachability matrix draw a directed graph (digraph), and remove transitive links.

(7) Convert the resultant digraph into an ISM, by replacing element nodes with statements.

(8) Review the ISM model to check for conceptual inconsistency, and make the necessary modifications.

Above described steps, which lead to the development of ISM model, are discussed below.

4.8.3 Structural self-interaction matrix (SSIM)

For analyzing the criteria a contextual relationship of "leads to" is chosen here. For developing contextual relationships among variables, expert opinions were considered. For expressing the relationship between different critical variables for coordination and responsiveness in Technical education.

Four symbols have been used to denote the direction of relationship between the parameters i and j (here i, j):

(1) V: parameter i will lead to parameter j;

(2) A: parameter j will lead to parameter i;

(3) X: parameter i and j will lead to each other; and

(4) O: parameters i and j are unrelated.

The following statements explain the use of symbols V, A, X and O in SSIM:

- variable 1 leads to 3 (V);
- variable 3and6 lead each other (X); and
- Variables 3 and 11 are unrelated (O).

Based on contextual relationships the SSIM is developed in Table 4.30.

Table 4.30 SSIM (Structural Self Interaction matrix)

S. No.	Enablers or Variables	2	3	4	5	6	7	8	9	10	11	12	13
1	Effective classroom management	A	V	A	A	A	A	V	V	A	A	A	V
2	Available regularly for students' consultation		V	O	O	A	A	V	V	A	O	O	V
3	Recognition of the students			O	O	O	A	X	V	O	O	O	V
4	Design of course structure based on job requirements				X	O	V	V	V	V	V	V	V
5	Comprehensive learning resources					O	X	O	V	A	A	A	V
6	Good communication skill of academic staff						X	V	O	X	O	O	V
7	Training on state-of-the-art technology							V	V	V	A	X	V
8	Close supervision of students' work								V	A	A	O	V
9	Opportunities for campus training & placement									A	A	A	V
10	Expertise in subjects and well-organised lectures										A	A	V
11	Adaptability to modern techniques											V	V
12	Well-equipped laboratories with modern facilities												V
13	Quality of Technical Education												

4.8.4 Reachability matrix

The SSIM (Structural Self Interaction matrix) has been converted into a binary matrix, called the initial reachability matrix by substituting V, A, X and O by 1 and 0 as per the case.

The substitution of 1s and 0s are as per the following rules:

(1) If the (i, j) entry in the SSIM is V, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0.

(2) If the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.

(3) If the (i, j) entry in the SSIM is X, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1.

(4) If the (i, j) entry in the SSIM is O, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

Table 4.31 IRM (Initial reachability matrix)

S. No.	Enablers or Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Effective classroom management	1	0	1	0	0	0	0	1	1	0	0	0	1
2	Available regularly for students' consultation	1	1	1	0	0	0	0	1	1	0	0	0	1
3	Recognition of the students	0	0	1	0	0	0	0	1	1	0	0	0	1
4	Design of course structure based on job requirements	1	0	0	1	1	0	1	1	1	1	1	1	1
5	Comprehensive learning resources	1	0	0	1	1	0	1	0	1	0	0	0	1
6	Good	1	1	0	0	0	1	1	1	0	1	0	0	1

	communication skill of academic staff													
7	Training on state-of-the-art technology	1	1	1	0	1	1	1	1	1	1	0	0	1
8	Close supervision of students' work	0	0	1	0	0	0	0	1	1	0	0	0	1
9	Opportunities for campus training & placement	0	0	0	0	0	0	0	0	1	0	0	0	1
10	Expertise in subjects and well-organised lectures	1	1	0	0	1	1	0	1	1	1	0	0	1
11	Adaptability to modern techniques	1	0	0	0	1	0	1	1	1	1	1	1	1
12	Well-equipped laboratories with modern facilities	1	0	0	0	1	0	1	0	1	1	0	1	1
13	Quality of Technical Education	0	0	0	0	0	0	0	0	0	0	0	0	1

Following above rules, the initial reachability matrix for the critical success factors is shown in Table 4.31. After incorporating the transitivity as described in Step (4) of the ISM methodology, the final reachability matrix is shown in Table 4.32 below.

Table 4.32 FRM (Final reachability matrix)

S. No.	Enablers or Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Effective classroom management	1	0	1	0	0	0	0	1	1	0	0	0	1

2	Available regularly for students' consultation	1	1	1	0	0	0	0	1	1	0	0	0	1
3	Recognition of the students	0	0	1	0	0	0	0	1	1	0	0	0	1
4	Design of course structure based on job requirements	1	1	1	1	1	1	1	1	1	1	1	1	1
5	Comprehensive learning resources	1	1	1	1	1	0	1	1	1	1	1	1	1
6	Good communication skill of academic staff	1	1	1	0	1	1	1	1	1	1	1	1	1
7	Training on state-of-the-art technology	1	1	1	1	1	1	1	1	1	1	1	1	1
8	Close supervision of students' work	0	0	1	0	0	0	0	1	1	0	0	0	1
9	Opportunities for campus training & placement	0	0	0	0	0	0	0	0	1	0	0	0	1
10	Expertise in subjects and well-organised lectures	1	1	1	1	1	1	1	1	1	1	1	1	1
11	Adaptability to modern techniques	1	1	1	1	1	1	1	1	1	1	1	1	1
12	Well-equipped laboratories with modern facilities	1	1	1	1	1	1	1	1	1	1	1	1	1
13	Quality of Technical Education	0	0	0	0	0	0	0	0	0	0	0	0	1

In Table, the driving power and dependence of each variable is also shown. Driving power for each variable is the total number of variables (including itself), which it may help to achieve.

On the other hand, dependence is the total number of variables (including itself), which may help in achieving it. These driving power and dependencies will be later used in the classification of variables into the four groups of autonomous, dependent, linkage and drivers (independent).

Table 4.33 FRM (Final reachability matrix with driving Power and dependence)

S. No.	Enablers or Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	Driving Power
1	Effective classroom management	1	0	1	0	0	0	0	1	1	0	0	0	1	5
2	Available regularly for students' consultation	1	1	1	0	0	0	0	1	1	0	0	0	1	6
3	Recognition of the students	0	0	1	0	0	0	0	1	1	0	0	0	1	4
4	Design of course structure based on job requirements	1	1	1	1	1	1	1	1	1	1	1	1	1	13
5	Comprehensive learning resources	1	1	1	1	1	0	1	1	1	1	1	1	1	12
6	Good communication skill of	1	1	1	0	1	1	1	1	1	1	1	1	1	12

	academic staff														
7	Training on state-of-the-art technology	1	1	1	1	1	1	1	1	1	1	1	1	1	13
8	Close supervision of students' work	0	0	1	0	0	0	0	1	1	0	0	0	1	4
9	Opportunities for campus training & placement	0	0	0	0	0	0	0	0	1	0	0	0	1	2
10	Expertise in subjects and well-organised lectures	1	1	1	1	1	1	1	1	1	1	1	1	1	13
11	Adaptability to modern techniques	1	1	1	1	1	1	1	1	1	1	1	1	1	13
12	Well-equipped laboratories with modern facilities	1	1	1	1	1	1	1	1	1	1	1	1	1	13
13	Quality of Technical Education	0	0	0	0	0	0	0	0	0	0	0	0	1	1
14	Dependence	9	8	11	6	7	6	7	11	12	7	7	7	13	

4.8.5 Level Partitions

The reach ability and antecedent set (Warfield, 1974) for each variable is found out from final reach ability matrix. The reach ability set for a particular variable consists of the variable itself and the other variables, which it may help to achieve. The antecedent set consist of the variables itself and the other variables, which may help in achieving them. Subsequently, the intersection of these sets is derived for all variables. The variables for which the reachability and the intersection are the same is given the top-level in the ISM hierarchy, which would not help achieve any other variable. After the identification of top-level element, it is discarded from the other remaining variables.

From the table given below, it is seen that quality of technical education (variable 13) is found at Level 1.Thus it would be positioned at the top of the ISM model. This iteration continued till the levels of each variable are found out. The identified levels aids in building the digraph and the final model of ISM. The variables, along with their reachability set, antecedent set, intersection set and the levels are shown in tables below.

ITERATION (1)

Variables	Reachability	Antecedent	Intersection	Level
1	1,3,8,9,13	1,2,4,5,6,7,10,11,12	1	
2	1,2,3,8,9,13	2,4,5,6,7,10,11,12	2	
3	3,8,9,13	1,2,3,4,5,6,7,8,10,11,12	3,8	
4	1,2,3,4,5,6,7,8,9,10,11,12,13	4,5,7,10,11,12	4,5,7,10,11,12	
5	1,2,3,4,5,6,7,8,9,10,11,12,13	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
6	1,2,3,5,6,7,8,9,10,11,12,13	4,5,6,7,10,11,12	5,6,7,10,11,12	
7	1,2,3,4,5,6,7,8,9,10,11,12,13	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
8	3,8,9,13	1,2,3,4,5,6,7,8,10,11,12	3,8	
9	9,13	1,2,3,4,5,6,7,8,9,10,11,12	9	
10	1,2,3,4,5,6,7,8,9,10,11,12,13	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
11	1,2,3,4,5,6,7,8,9,10,11,12,13	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
12	1,2,3,4,5,6,7,8,9,10,11,12,13	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
13	13	1,2,3,4,5,6,7,8,9,10,11,12,13	13	I

ITERATION (2)

Variables	Reachability	Antecedent	Intersection	Level
1	1,3,8,9	1,2,4,5,6,7,10,11,12	1	
2	1,2,3,8,9	2,4,5,6,7,10,11,12	2	
3	3,8,9	1,2,3,4,5,6,7,8,10,11,12	3,8	
4	1,2,3,4,5,6,7,8,9,10,11,12	4,5,7,10,11,12	4,5,7,10,11,12	
5	1,2,3,4,5,6,7,8,9,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
6	1,2,3,5,6,7,8,9,10,11,12	4,5,6,7,10,11,12	5,6,7,10,11,12	
7	1,2,3,4,5,6,7,8,9,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
8	3,8,9	1,2,3,4,5,6,7,8,10,11,12	3,8	
9	9	1,2,3,4,5,6,7,8,9,10,11,12	9	II
10	1,2,3,4,5,6,7,8,9,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
11	1,2,3,4,5,6,7,8,9,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
12	1,2,3,4,5,6,7,8,9,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
13				

ITERATION (3)

Variables	Reachability	Antecedent	Intersection	Level
1	1,3,8	1,2,4,5,6,7,10,11,12	1	
2	1,2,3,8	2,4,5,6,7,10,11,12	2	
3	3,8	1,2,3,4,5,6,7,8,10,11,12	3,8	III
4	1,2,3,4,5,6,7,8, ,10,11,12	4,5,7,10,11,12	4,5,7,10,11,12	
5	1,2,3,4,5,6,7,8,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
6	1,2,3,5,6,7,8,10,11,12	4,5,6,7,10,11,12	5,6,7,10,11,12	
7	1,2,3,4,5,6,7,8,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
8	**3,8**	1,2,3,4,5,6,7,8,10,11,12	**3,8**	**III**
9				
10	1,2,3,4,5,6,7,8,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
11	1,2,3,4,5,6,7,8,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
12	1,2,3,4,5,6,7,8,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
13				

ITERATION (4)

Variables	Reachability	Antecedent	Intersection	Level
1	1	1,2,4,5,6,7,10,11,12	1	IV
2	1,2	2,4,5,6,7,10,11,12	2	
3				
4	1,2, 4,5,6,7, 10,11,12	4,5,7,10,11,12	4,5,7,10,11,12	
5	1,2,4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
6	1,2,5,6,7,10,11,12	4,5,6,7,10,11,12	5,6,7,10,11,12	
7	1,2,5,6,7,8,9,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
8				
9				
10	1,2,4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
11	1,2,4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
12	1,2,4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	

ITERATION (5)

Variables	Reachability	Antecedent	Intersection	Level
1				
2	**2**	2,4,5,6,7,10,11,12	**2**	**V**
3				
4	2, 4,5,6,7, 10,11,12	4,5,7,10,11,12	4,5,7,10,11,12	
5	2,4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
6	2,5,6,7,10,11,12	4,5,6,7,10,11,12	5,6,7,10,11,12	
7	2,4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
8				
9				
10	2,4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
11	2,4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
12	2,4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
13				

ITERATION (6)

Variables	Reachability	Antecedent	Intersection	Level
1				
2				
3				
4	4,5,6,7, 10,11,12	4,5,7,10,11,12	4,5,7,10,11,12	
5	4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
6	**5,6,7,10,11,12**	4,5,6,7,10,11,12	**5,6,7,10,11,12**	**VI**
7	4,5,6,7,8,9,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
8				
9				
10	4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
11	4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	4,5,6,7,10,11,12	
13				

ITERATION (7)

Variables	Reachability	Antecedent	Intersection	Level
1				
2				
3				
4	4	4	4	VII
5	4	4	4	VII
6				
7	4	4	4	VII
8				
9				
10	4	4	4	VII
11	4	4	4	VII
12	4	4	4	VII
13				

4.8.6 Formation of ISM based Model

From above iteration process we found around seven different levels. At each level we identified certain variables that must take care. Design of course structure based on job requirements (variable 4) is a very significant variable and it comes at the base (level 7) of the ISM hierarchy.

While Quality of Technical Education (Variable 13) is the goal of this analysis appeared at the top (level 1) of the hierarchy result in improvement of quality of Technical education. Comprehensive learning resources (Variable 5), Good communication skill of academic staff (Variable 6), Training on state of the art technology (Variable 7), Expertise in subjects and well organized lectures (Variable 10), Adaptability to modern techniques (Variable 11) and well equipped laboratories with modern facilities (Variable 12) are collectively stands at level 6.this suggest that all these factor are interrelated and must take care collectively. Available regularly for students' consultation (Variable2) stands at level 5, Effective classroom management stands at level (Variable 1) stands at level 4 , Recognition of the students (Variable 3) and Close supervision of students' work (Variable8) are related with each other and stand at level 3 Opportunities for campus training & placement (Variable 9) stands at level 2 in ISM based model.

Table (4.34) below show the list of variables and their ISM based Rank. Figure (8) shows the ISM model for TES along with their levels.

Table 4.34 ISM based rank of variables

Sr. No.	Variables	Rank
1	Effective classroom management	4
2	Available regularly for students' consultation	3
3	Recognition of the students	5
4	Design of course structure based on job requirements	1
5	Comprehensive learning resources	2
6	Good communication skill of academic staff	2
7	Training on state-of-the-art technology	2
8	Close supervision of students' work	5
9	Opportunities for campus training & placement	6
10	Expertise in subjects and well-organised lectures	2
11	Adaptability to modern techniques	2
12	Well-equipped laboratories with modern facilities	2
13	Quality of Technical Education	7

<table>
<tr><th colspan="6">Variables</th><th>Level</th></tr>
<tr><td colspan="6">Quality of Technical Education</td><td>1</td></tr>
<tr><td colspan="6">Opportunities for campus training & placement</td><td>2</td></tr>
<tr><td colspan="6">Close supervision of students' work</td><td>3</td></tr>
<tr><td colspan="6">Effective classroom management</td><td>4</td></tr>
<tr><td colspan="6">Available regularly for students' consultation</td><td>5</td></tr>
<tr><td>Comprehen -sive learning resources</td><td>Good communic -ation skill of academic staff</td><td>Training on state-of-the-art technology</td><td>Expertise in subjects and well-organised lectures</td><td>Adaptability to modern techniques</td><td>Well-equipped laboratories with modern facilities</td><td>6</td></tr>
<tr><td colspan="6">Design of course structure based on job requirements</td><td>7</td></tr>
</table>

Figure 4.7 ISM Based model for TES variables

4.8.7 Driving power and dependence diagram

The objective of this diagram is to analyze the driver power and the dependence power of the variables. The variables are classified in to four clusters figure (4.8).The first cluster consists of the autonomous variables that have weak drive power and weak dependence. These variables are relatively disconnected from the system, with which they have only few links, which may be strong. Second cluster consists of the dependence variables that have weak driver power but strong dependence.

Third cluster has the linkage variables that have strong driving power and also strong dependence. These variables are unstable in the fact that any action on these variables will have an effect on others .Fourth clusters includes the independent variables having strong driving power but weak dependence. It is observed that a variable with a very strong driving power called the key variables.

The driving power and dependence of each of the variables are shown in table (FRM). In this table; an entry of "1"along the column and rows indicates the dependence and driving power, respectively. Here, the Driver-power and dependence diagram is constructed which is shown in figure (4.8). This figure shows that variable 10 has driving power 13 and dependence 7. Therefore in this figure, it is positioned at a place corresponding to driver power of 13 and dependency of 7.

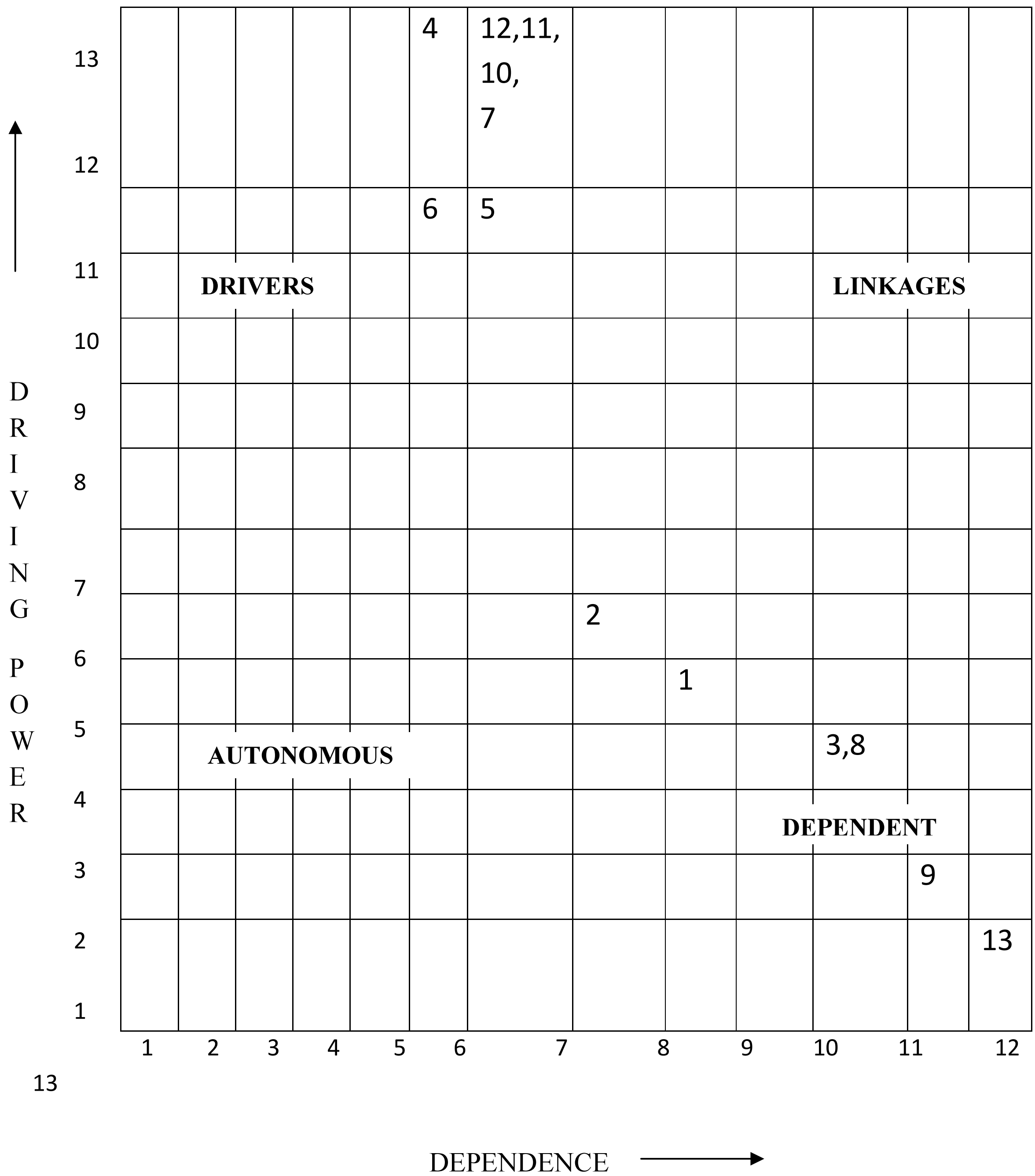

Figure 4.8 Driving power and dependence diagram

4.8.8 Results and Discussions

The objective of the ISM model used in this research is to develop a hierarchy of enablers which would help in improving the quality of technical education. These enablers are important input for upgrading the standard of technical education and to compete the fast changing technology. Quality of Technical education can improve in effective manner if all the variables are improved in the given hierarchy. The driver dependence diagram helps to classify various enablers of effective Technical education system. There are no variables in the autonomous cluster, which indicates no variable can be considered as disconnected from the other variables and pay an attention to all the identified enablers for improving the quality of Technical education. In the next cluster we have Effective classroom management, Available regularly for students' consultation, Recognition of the students, Close supervision of students' work, Opportunities for campus training & placement, Quality of Technical Education which have low driving power and high dependency that means they are dependent on the driving enablers. There are no linkage enablers which has a strong driving power as well as strong dependence. Thus, it can be inferred that among all the 13 enablers chosen in this study, no enabler is unstable. The driver power dependence diagram indicates that enablers such as Design of course structure based on job requirements, Well-equipped laboratories with modern facilities, Adaptability to modern techniques, Expertise in subjects and well-organized lectures, Training on state-of-the-art technology, Good communication skill of academic staff, Comprehensive learning resources are at the bottom of the model having strong driving power and low dependency. These enablers will help to achieve its desired objective and are classified as independent enablers or drivers.

On the basis of ISM model it is concluded that the variables "Design of course structure based on job requirements" is ranked as no. 1.

Variables "Comprehensive learning resources", "Good communication skill of academic staff", "Expertise in subjects and well-organized lectures", "Adaptability to modern techniques" and "Well-equipped laboratories with modern facilities" are ranked as no.2.

Variable "Available regularly for students' consultation" is ranked as no. 3.
Variable "Effective classroom management" is ranked as no.4.
Variable "Recognition of the students" is ranked as no. 5.
Variable "Opportunities for campus training & placement" is ranked as no. 6.

Variable "Quality of Technical Education" is ranked as no. 7, which is the final/ desired objective of the study.

Chapter 5
Comparative Study of Engineering Colleges

Improvement in the quality of Technical Education is mainly based on comparative study in various Engineering colleges in the University System. The grading of engineering colleges in term of excellence is governed by various parameters. The case studies of different Engineering colleges have been taken up in this chapter.

5.1 Case Study No. 8 Ranking of Engineering Colleges based on Statistical Method and Survey Analysis to Assess the Quality in Technical Education*

5.1.1 Introduction:

In present dynamic educational environment, the college ranking reflects as to where Indian higher education stands today. The parameter of ranking is the established benchmark for quality education and it also lets us know what is required. The purpose of these ranking is never to merely keep score but to reveal where there is real change and development. Ranking are based on subjectively perceived quality on some combination of statistics or surveys of educators, scholars, students, and other relevant factors. Here the engineering colleges have been categorized in Delhi as A, B, C and so on as per the data available based on some parameters. The institutions taken in this ranking are Institute No. 1, Institute No. 2, Institute No.3, 'X' University (*several colleges affiliated by 'X' university*).

5.1.2 Ranking Parameters involved in the "RANKING AND COMPARATIVE STUDY OF ENGINEERING COLLEGES":

The parameters taken into consideration for the ranking of engineering college are:-

1. ISO certification
    - ISO certification of college
    - ISO certification of Department
    - For ISO certification of Laboratory

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ISO stands for International Organization for Standardization. It is a worldwide federation of national standard bodies and presently it has 140 members having one in each country. The object of ISO is to promote the development of standardization and related activities in the world. It facilitates international exchange of goods and services and also develops co-operation in the spheres of intellectual, scientific, and economic activities.

ISO 9000 family of standards represents an international consensus on good management practices with aim of ensuring that the organization can time and again deliver services that meet the quality requirement. The family of ISO standards have been developed by ISO and it is made up of 4 code standards:

- ISO 9000:2000 - Fundamentals & Vocabulary
- ISO 9001:2000 - Quality Management System - Requirement
- ISO 9004:2000 - Quality Management System- Guidelines for performance improvement
- ISO 19011:2002 - Guidelines for quality/environmental management System auditing.

The ranking of engineering colleges must be done on this basis to improve the quality of education to have a real change and development. Other methodologies can also be adopted like Artificial Neural Network (ANN).

2. Accreditation of courses
   - Accreditation of institute
   - Accreditation of department
   - Accreditation of laboratory
   - Accreditation B.E. courses
   - Accreditation of M.E. courses

Educational accreditation is a type of quality assurance process under which services and operation of post-secondary educational institutions or programmes are evaluated by an external body to determine if applicable standards are met.

Accredited status is granted by the agency. This accreditation is given by NAAC (National Assessment and Accreditation Council) and it is an autonomous body funded by University Grants Commission of Government of India based in Bangalore. Accreditation is compulsory for all universities in India except those created through an act of Parliament. Without accreditation," It emphasized that these fake institutions have no legal entity to call themselves as University and to award degrees which are not treated as valid for academic/employment purpose.

The University Grants Commission Act (1956) explains:

"The right of conferring or granting degree shall be exercised only by a University established or incorporated by or under a Central Act, or an institution deemed to be University or an institution specially empowered by an Act of the Parliament to confer or grant degrees. Thus any institution which has not been created by an enactment of Parliament or a State Legislature or has not been granted the status of Deemed University and is not entitled to award a degree".

3. Post Graduate courses offered
4. Passing percentage of student at B.E. Level
5. Number of faculty having Ph.D degree
6. Research centres in college/institute
7. Student placement
8. Research scheme offered

Proposal:

On the basis of above parameters following scheme has been suggested which give ample scope for self correction.

S. No.	Impact Parameter	Maximum marks (%)	Suggested distribution of marks
1	ISO Certification	15	
2	Accreditation of courses	20	2 marks per course
3	PG Courses offered	10	1 marks per course
4	Pass %age of student in final year	15	95%-100% 15 85%-94% 10 75%-84% 8 60%-74% 5 Below 60% 0

5	Number of faculty having PhD degree	10	Above 80% 10 60%-79% 8 40%-59% 6 20%-39% 4 10%-19% 2 Below 10% 1
6	Research centre	10	2 marks per research centre
7	Student placement	10	Above 95% 10 85%-94% 8 75%-84% 6 65%-74% 4 50%-64% 2 Below 50% 1
8	Research scheme offered	10	2 marks per research scheme or papers published in reviewed journals; Books published through international publishers

Grading Criterion:

S. No.	PERCENTAGE	GRADE
1	>80%	Centre of excellence
2	60%-79%	A
3	50%-60%	B
4	40%-50%	C
5	< 40%	D (need to improve)

Grade D: College should be given time for improvement so that they enhance their quality of education to have a better future of student admitted into that institution.

5.1.3 LIST OF COLLEGES CONSIDERED:

1. Institute No. 1
2. Institute No. 2
3. Institute No. 3
4. 'X' University
    - Institute No. 4
    - Institute No. 5
    - Institute No. 6
    - Institute No. 7
    - Institute No. 8
    - Institute No. 9
    - Institute No. 10
    - Institute No. 11
    - Institute No. 12
    - Institute No. 13
    - Institute No. 14

5.1.4 CASE STUDY OF VARIOUS COLLEGES

CASE STUDY: How the points are allotted for ranking of the colleges.

CASE STUDY: INSTITUTE NO. 1

1) ISO Certification – NO
2) Accreditation of courses
Courses offered by Institute No. 1 are not officially recognised
Maximum points achieved = 0
3) PG Courses offered = 17

Structural Engineering	Production engineering
Environmental Engineering	Information system
Hydraulic engineering	Polymer engineering
Geotechnical Engineering	Computer technology & application

Signal processing	Software engineering
Microwave & Optical Communication	Nano science & Technology
VLSI Design & Embedded system	Bioinformatics
Power system	
Thermal engineering	

Maximum points achieved on this parameter = 10

4) Passing % of student in final year is around 95%-100%
Points achieved on this basis = 15

5) Number of faculty having PhD degree:
Total number of faculty = 153
Number of faculty having PhD degree = 68
% of faculty having PhD degree = (68/153)*100 = 44.44%
Points achieved on this basis = 6

6) Research centre:

- Centre of Relevance and Excellence in Optical Fiber and Optical Communications under joint sponsorship of TIFAC-CORE, the Department of Science and Technology, Government of India and Government of N.C.T., Delhi.
- Material science research group involving applied Physics and Polymer Science and Chemical Technology.
- Institute No. 1 has a strong Bio-Diesel Research Group which has carried out commendable research and development work in the area of Biodiesel Reactor Design.
- The Institute No. 1 Hybrid Car designed and developed by the student team in the year 2005 has won the first place in the student category in the Green Car competition in US.
- The Institute No. 1 super mileage vehicle designed and developed by an interdisciplinary team of student in the year 2005 won the best design award at the world competition organized by the SAE international at Marshall Michigan, USA-2005.
- The Institute No. 1 Student Team has also designed and developed an unmanned aircraft equipped with surveillance capabilities and won, 'The Directors Award' at the international AUVIS competition in 2009.

Points achieved on this basis = 10

7) Student placement:

Campus placement of graduating students of Institute No. 1 has always been very high.

- The batch graduating in 2010, has received 660 offers from 125 companies which visited Institute No. 1 campus during the year.
- The highest overseas salary offered this year is Rs. 14.0 lacs
- Highest domestic salary is Rs. 11 lacs p.a.
- The average salary has gone upto Rs. 5.5 lacs p.a.
- About 90%-95% of the total intake got placement.

Points achieved on this basis = 10

8) Research scheme offered

As per the paper published in peer reviewed journal and book published through international publisher, points achieved on this basis is 10

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	-
2	Course Accreditation	20	-
3	PG Courses offered	10	10
4	Pass % of student in final year	15	15
5	Number of faculty having PhD degree	10	6
6	Research centres	10	10
7	Student placement	10	10
8	Research scheme offered	10	10
	Total	**100**	**61**

Grade allotted = A

CASE STUDY: INSTITUTE NO. 2

1) ISO Certification
   Institute No. 2 is approved by AICTE.
2) Accreditation of courses
   Courses offered by Institute No. 2 is not officially recognized by NBA & AICTE
   So points achieved on this basis = 0
3) PG Courses offered = Around 20

Bipolar & MOS Analogue Integrated Circuits	Computer architecture
Current mode signal processing switch capacitor	CAD
Digital signal processing	CAM
Statistical signal processing	CIM
Digital communication	Optoelectronics
Information system	Molecular biology
Software engineering	
Embedded and real time systems	

Marks achieved on this basis = 20

4) Passing %age of student in final year is around 95%-100%
   Points achieved on this basis = 15
5) Number of faculty having PHD degree
   Total number faculty in Institute No. 2 = 87
   Number of faculty having doctoral degree = 52
   %age of faculty having doctoral degree = (52/87)*100 = 59.77
   Points achieved on this basis = 8
6) Research and research centres
   - Institute No. 2 is developing science & technology park through public private partnership

- In electronics division around 205 papers are published in international journal from 1990 till date and around 14 books through international publisher
- In computer science 36 papers are published in international journal from 1994 till date and around 5 books are published through international publisher.
- In instrumentation & control 34 papers are published till date in international journal.
- In manufacturing and automation engineering division 41 papers are published in international journal.
- In IT section 36 international papers and 5 books are published by international publisher 62 papers are being presented till date.
- In biotechnology division 33 papers, 4 books are published by international publisher and 3 student publications are also there.

S. No.	Department	Papers published in international journal	Books published by international publisher
1	ECE	205	14
2	CSE	36	5
3	ICE	34	-
4	MAE	41	-
5	IT	36	5
6	BIOTECHNOLOGY	33	4

Points achieved on the parameter "research scheme offered" = 10

7) Student placement

	2006-07	2007-08	2008-09
Total no. of companies visiting the campus	70	83	81
Average Package *(in lacs per annum)*	5.28	5.90	5.65

Highest Salary offered *(in lacs per annum)*	45.00	45.00	22.00
Total no. of offers made	779	801	742
No. of international offers	9	22	7

Almost 95%-100% of the total intake gets placed by different recruiters.

So points scored on this basis = 10

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	-
2	Course Accreditation	20	-
3	PG Courses offered	10	10
4	Pass % of student in final year	15	15
5	Number of faculty having PhD degree	10	8
6	Research centres	10	4
7	Student placement	10	10
8	Research scheme offered	10	10
	Total	100	57

Grade allotted = B

<u>CASE STUDY: INSTITUTE NO. 3</u>

Points obtained out of 100 = 41

Grade allotted = C

CASE STUDY: 'X' UNIVERSITY

CASE STUDY: INSTITUTE NO. 4

1) ISO Certification – NO
2) Accreditation of courses
   Courses offered by this institution are officially recognized by NBA &AICTE.
   Courses available in this institution:

S.NO	COURSES	APPROVAL
1	Mechanical	AICTE
2	Civil	NBA & AICTE
3	Electrical & Electronics	AICTE
4	Computer Science & Engg	NBA
5	Information Science & Engg	NBA

   Total number of courses offered = 5
   So points achieved on this basis = **10**
3) PG Courses offered
   M.Tech. in Computer Science & Engineering
   M.Tech. in VLSI Design &Embedded system
   Master in Computer Application (MCA)
   Master in Business Administration (MBA)
   So total number of points achieved on this basis = 4
4) Passing percentage of student in final year is around 90%
   So points achieved on this basis = 15
5) Number of faculty having PHD degree
   Total strength = 167
   Doctoral Degree = 13
   Percentage having doctoral degree = (13/167)*100 = 7.78
   So points achieved on this basis = 1
6) Research & Research centres
   - A professor of Mechanical department won best research paper award on "Measuring of Transmission Error of Gearboxes " at the National Symposium of Acoustics, which was held during Oct'30-Nov'01-2003, Pune.

- Department of Industrial Engineering is carrying research on "Welding of Aluminium Silicon Carbide" & "Metal Matrix Composite"
- Department of Telecom Engineering is carrying seminar on 2 AICTE-MODROB projects on:
  Modernization of VLSI &Signal processing
  Modernization of Microwave Communication Lab

Apart from these, department of Computer Science & Engineering published 25 International Technical Journals.

Total points achieved on this basis = 8

7) Student Placement

Around 90% of the total intakes get placed by different recruiters.

So points achieved on this basis = 8

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	-
2	Course Accreditation	20	10
3	PG Courses offered	10	4
4	Pass % of student in final year	15	15
5	Number of faculty having PhD degree	10	1
6	Research centres	10	-
7	Student placement	10	8
8	Research scheme offered	10	8
	Total	**100**	**46**

Grade allotted = C

CASE STUDY: INSTITUTE NO. 5

1) ISO Certification

   This college is certified by ISO

   So points achieved on this basis = 15

2) Course Accreditation
   Courses offered by this institution are:

S. No.	COURSES	APPROVAL
1	Applied Sciences	AICTE
2	Computer Science & Engg	NBA
3	Electronics & Communication Engg	AICTE
4	Electrical & Electronics	AICTE
5	Instrumentation & Control	NBA
6	Information Technology	NBA

So number of courses accredited = 6

So points achieved on this basis = 12

3) PG Courses offered
   This institution doesn't offer post graduate courses
   So points achieved on this basis = 0
4) Number of faculty having PHD degree

S. No.	Faculty (Department)	Total	PHD
1	Applied Science	17	8
2	CSE	18	1
3	ECE	24	1
4	EEE	12	2
5	ICE	12	1
6	IT	16	1
		99	**14**

So percentage of faculty having Doctoral Degree = (14/99)*100 = 14.14%
   So points achieved on this basis = 2

5) Student Placement

S. No.	Year	%age placed
1	2001-2005	75%
2	2002-2006	85%
3	2003-2007	93%
4	2004-2008	97%
5	2005-2009	80%
	Average	86%

So average %age placement of student in this college is around 86%
So points allotted on this basis = 8

6) Passing %age of student in final year is around 100%.
So points allotted on this basis = 15

7) Research and Research centre

A separate R&D cell is established and working with the objective to support PHD scholars, research activities, project proposals and writing research papers for national and international journal and conferences. Major research areas include:

- Value added services in communication system
- Tsunami: Radio alert system
- Sustainable built environment
- Image processing
- Nano technology
- VLSI Technology
- Embedded system

So points obtained on the basis of this parameter = 2

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	15
2	Course Accreditation	20	12
3	PG Courses offered	10	-
4	Pass % of student in final year	15	15

5	Number of faculty having PhD degree	10	2
6	Research centres	10	2
7	Student placement	10	8
8	Research scheme offered	10	-
	Total	**100**	**54**

Grade allotted = B

CASE STUDY: INSTITUTE NO. 6

1) ISO Certification
   This college is AICTE approved. This was specially established to impart engineering facility to girls of the country.
2) Course Accreditation
   Institute No. 6 offers following course which are officially recognized:
   Computer science & engineering
   Electronics & communication engineering
   Mechanical & automation
   Electrical & electronics engineering
   So points achieved on this basis = 10
3) PG Courses offered
   Institute No. 6 offers post graduate degree in Electrical & Electronics Engineering on weekend basis. In 2010-2011
   So points achieved on this basis = 1
4) Number of faculty having PhD degree

S. No.	Department	Total	PHD
1	CSE	8	1
2	ECE	13	3
3	MAE	6	1
4	Applied Sciences	5	4
		32	**9**

Total number of faculty in Institute No. 5 = 32
Number of faculty having PhD degree = 9
Then, %age of faculty having doctoral degree = (9/32)*100 = 28.15%
So points allotted on this basis = 4

5) Student placement
A cluster of companies visit Institute No. 6 for campus recruitment such as Microsoft, GE, TCS, Adobe, Tech-Mahindra, Sapient, Infosys, Mahindra & Mahindra, Siemens. The placement is nearly 90%-95%.
So points achieved on this basis = 8

6) Research & Research Centers
    - Carrying project on Design & Fabrication of All Terrain Vehicle Project-2008 funded by Maruti and All Terrain Vehicle -2009 funded by SAIL.

   So points achieved on this parameter = 2

7) Passing %age of student in final year is almost 100%
So points scored on this parameter = 15

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	15
2	Course Accreditation	20	10
3	PG Courses offered	10	1
4	Pass % of student in final year	15	15
5	Number of faculty having PHD degree	10	4
6	Research centres	10	-
7	Student placement	10	8
8	Research scheme offered	10	2
	Total	**100**	**55**

Grade allotted = B

CASE STUDY: INSTITUTE NO. 7

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	15
2	Course Accreditation	20	4
3	PG Courses offered	10	2
4	Pass % of student in final year	15	15
5	Number of faculty having PhD degree	10	6
6	Research centres	10	2
7	Student placement	10	8
8	Research scheme offered	10	4
	Total	**100**	**56**

Grade Allotted = B

CASE STUDY: INSTITUTE NO. 8

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	15
2	Course Accreditation	20	4
3	PG Courses offered	10	2
4	Pass % of student in final year	15	15
5	Number of faculty having PhD degree	10	10
6	Research centres	10	2
7	Student placement	10	6
8	Research scheme offered	10	4
	Total	**100**	**58**

Grade allotted = B

CASE STUDY: INSTITUTE NO. 9

1) ISO Certification
This college is approved by AICTE.

2) Course Accreditation
Courses offered by this institute are:
ECE (ELECTRONICS & COMMUNICATION ENGINEERING)
CSE (COMPUTER SCIENCE & ENGINEERING)
IT (INFORMATION TECHNOLOGY)
MAE (MECHANICAL & AUTOMATION ENGINEERING)
EEE (ELECTRICAL & ELECTRONICS ENGINEERING)
MBA (MASTER IS BUSINESS ADMINISTRATION)
So points achieved on this basis = 12

3) PG Courses offered
This institute provide PG course in MBA only
So points scored on this basis = 1

4) Number of faculty having PhD degree
Total number of faculty in the institute = 120
Number of faculty having doctoral degree = 11
So %age of faculty having doctoral degree = (11/120)*100 =9.16%
So points scored on this parameter = 1

5) Student placement
Around 80% of the total intake gets placed through different recruiters
So points achieved on this parameter = 6

6) Nearly 95%-100% of the student passes who appear in the final year examination.
So points obtained on this parameter = 15

7) Research & research centres
This college needs a lot to improve in this field.
Points allotted = 2

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	-
2	Course Accreditation	20	12
3	PG Courses offered	10	1
4	Pass % of student in final year	15	15

5	Number of faculty having PhD degree	10	1
6	Research centres	10	-
7	Student placement	10	6
8	Research scheme offered	10	2
	Total	**100**	**37**

Grade allotted = D

So this college needs to improve in field of research to have better education and good future of the student admitted there.

<u>CASE STUDY: INSTITUTE NO. 10</u>

1) ISO Certification
Institute No. 10 is AICTE approved college.
2) Course Accreditation
Courses offered by this institution are:
BDA
B.TECH (IT)
BCA
MBA
So points obtained on this basis = 8
3) PG Courses offered
Institute No. 10 provides post graduate course in MBA only.
So points achieved on this basis = 1
4) Number of faculty having doctoral degree
Total number of faculty in the college = 54
Number of faculty having doctoral degree = 9
So %age of faculty having PhD degree = (9/54)*100 = 6%
So points achieved on this basis = 1
5) Student placement
Around 80% of the total intake gets placed by different recruiters

So points scored on this basis = 6
6) Passing %age of student appearing in final year is around 95%-100%.
So points allotted on the basis of this parameter = 15

7) Research & research centres
2 research papers are being published in international journal in IT department
So points allotted on the basis of this parameter = 2

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	-
2	Course Accreditation	20	8
3	PG Courses offered	10	1
4	Pass % of student in final year	15	15
5	Number of faculty having PhD degree	10	1
6	Research centres	10	-
7	Student placement	10	6
8	Research scheme offered	10	2
	Total	**100**	**33**

Grade allotted = D

So this college also needs to improve in field of research and courses offered.

CASE STUDY: INSTITUTE NO. 11

1) ISO Certification
This college is approved by AICTE
2) Course Accreditation
Courses offered by this university are:
Electrical & Electronics Engineering
Computer Science & Engineering
Electronics & Communication
Information Technology
So points obtained on this parameter = 8

3) PG Courses offered
This institute doesn't offer PG course in engineering
So points allotted on this parameter = 0

4) Number of faculty having PhD degree
   Total number of faculty in this college = 30
   Faculty having doctoral degree = 4
   So %age of faculty having PhD degree = 7.5%
   So points allotted on the basis of this parameter = 1
5) Student placement
   Around 66% of the total intake is placed by different recruiters
   So points obtained on this basis = 4
6) Almost 95% of the total intake clears the final examination
   So points achieved on this parameter = 15

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	-
2	Course Accreditation	20	8
3	PG Courses offered	10	-
4	Pass % of student in final year	15	15
5	Number of faculty having PhD degree	10	1
6	Research centres	10	-
7	Student placement	10	4
8	Research scheme offered	10	-
	Total	**100**	**28**

Grade allotted = D

Needs improvement

CASE STUDY: INSTITUTE NO. 12

1) ISO Certification
   Approved by AICTE
2) Course Accreditation
   Course offered
   EEE
   ECE
   CSE
   IT
   So points allotted on the basis of this parameter = 8
3) PG Courses offered
   This institute doesn't provide PG course in engineering
   So points achieved on this basis = 0
4) Number of faculty having PhD degree
   Total number of faculty in this college = 36
   Number of faculty having doctoral degree = 11
   %age having PhD degree = 30.55%
   So points allotted on this basis = 4
5) Almost 95% of the total intake pass in the final examination
   So points scored on this parameter = 15
6) Student placement
   Around 72% of the total intake got placed by different recruiters
   So points obtained on this basis = 4

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	-
2	Course Accreditation	20	8
3	PG Courses offered	10	-
4	Pass % of student in final year	15	15
5	Number of faculty having PhD degree	10	4
6	Research centres	10	-
7	Student placement	10	4

8	Research scheme offered	10	-
	Total	**100**	**31**

Grade allotted = D

Needs improvement

CASE STUDY: INSTITUTE NO. 13

1) ISO Certification
   College is affiliated by AICTE.
2) Course Accreditation
   List of courses available and officially recognized:
   Computer Science & Engineering
   Electronics & Communication Engineering
   Mechanical & automation Engineering
   So points secured on this parameter = 8
3) PG courses offered
   Not available in engineering stream
   Point achieved = 0
4) Number of faculty having PhD degree
   Total number of faculty = 66
   Number of faculty having PhD degree = 13
   %age having PhD degree = (13/66)*100= 19.6%
   So points achieved = 2
5) Around 65% of the total intake get placed
   So points achieved = 4
6) Passing %age of student appearing in final year = 90%
   So points secured = 10

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	-
2	Course Accreditation	20	8
3	PG Courses offered	10	-
4	Pass % of student in final year	15	10
5	Number of faculty having PhD degree	10	2

6	Research centres	10	-
7	Student placement	10	4
8	Research scheme offered	10	-
	Total	**100**	**24**

Grade allotted = D

<u>CASE STUDY: INSTITUTE NO. 14</u>

1) ISO Certification
   AICTE approved
2) Course Accreditation
   List of courses available & officially recognized:
   ECE
   CSE
   IT
   B.PHARMACEUTICALS
   So points secured = 8
3) PG Courses offered
   Not available in engineering stream
4) Number of faculty having PhD degree
   Total number of faculty in the institution = 38
   Number of faculty having doctoral degree = 3
   %age of faculty having PhD degree = (3/38)*100 = 7.89%
   So points achieved = 1
5) Student placement
   Around 75% of the total intake get placement
   So points secured = 6
6) Passing %age of student in final year = 95%
   So points secured =15
7) Research and research centres
   The institution has its own R&D cell which guides the students in their various projects, writing international papers and a project on automation is also being carried out.
   So points allotted on this basis = 2

S. No.	Parameters	Maximum points	Points obtained
1	ISO Certification	15	-
2	Course Accreditation	20	8
3	PG Courses offered	10	-
4	Pass % of student in final year	15	15
5	Number of faculty having PhD degree	10	1
6	Research centres	10	2
7	Student placement	10	6
8	Research scheme offered	10	-
	Total	**100**	**32**

Grade allotted = D

Government Colleges/University

Rank	**College /University**	**Points obtained out of 100**	**Grade**
1	Institute No. 1	61	A
2	Institute No. 2	57	B
3	Institute No. 3	41	C

Private Colleges/University

Rank	College/University	Points obtained out of 100	Grade
1	Institute No. 8	58	B
2	Institute No. 7	56	B
3	Institute No. 6	55	B
4	Institute No. 5	54	B
5	Institute No. 4	46	C
6	Institute No. 9	37	D
7	Institute No. 10	33	D
8	Institute No. 14	32	D
9	Institute No. 12	31	D
10	Institute No. 11	28	D
11	Institute No. 13	24	D

5.1.5 Conclusions:

The ranking of the colleges is important in the university system since it indicates the scope of improvement of the institute. Analysis has been done to find out the weak areas in which the improvement of the quality is needed.

Institutes having better quality of the faculty, placement of the students, Infrastructure and management inputs are found as higher in the ranking. The technique used is quite helpful in university system also.

Ranking of colleges has been prepared on the basis of eight parameters. The Grade D college needs to improve their quality in technical education.

There should be adequate research activities and institution should enhance this activity on a broader spectrum. Comparative results are arranged in a tabular form for a better understanding of quality status of these institutes.

References

1. P.Venkataram and Anandi Giridharan, "Quality Assurance and Assessment in Technical Education System: A Web Based Approach", ICEE 2007.

2. Deming, W.E. (1991, March), "A System of profound knowledge", International Quality Seminar, Santa Clara, CA, US.

3. Juran, J.M. (Ed.). (1974). Quality control handbook (3rd Ed.). New York: McGraw-Hill.

4. W. G. Ainslie, M.A., B.Sc., M.I. Prod. E. "Changes in technical education".

5. William j. Underwood, Member, IEEE, "In House Technical Education: Current Status- Future Directions", IEEE Transactions on Education", Vol. E-19, No.1, February 1976.

6. Zhongming Liang, "Total Quality Control in Education", 1991 Frontiers in Education Conference.

7. Philip H. Swain and Edward R. Alef, "Optimizing Graduate Education for Today's Practicing Engineers", 1991 Frontiers in Education Conference.

8. Gordan. S. Kalley, "Quality in Education", 1991 Frontiers in Education Conference.

9. Majid Jaraiedi and David Ritz, "Total Quality Management Applied to Engineering Education", Quality Assurance in Education Year: 1994 Volume: 2 Issue: 1 Page: 32 – 40.

10. Becher, T., Embling, J. and Kogan, M. (1978), Systems of Higher Education: United Kingdom, International Council for Educational Development.

11. Besterfield, D.H., Besterfield-Michna, C. and Besterfield-Sacre, M. (1999), Total Quality Management, Prentice-Hall, Englewood Cliffs, NJ.

12. Shattock, M. (Ed.) (1996), "The Creation of a University System", Blackwell Publishers, Cambridge, MA.

13. Samuel K. Ho and Katrina Wearn, "A TQM model for higher education and training", Training for Quality Volume 3 · Number 2 · 1995 · pp. 25–33 © MCB University Press · ISSN 0968-4875.

14. Clive Colling and Lee Harvey," Quality control, assurance and assessment – the link to continuous improvement", Quality Assurance in Education Volume 3 · Number 4 · 1995 · pp. 30–34 © MCB University Press · ISSN 0968-4883

15. Erika Martens and Michael Prosser, "What constitutes high quality teaching and learning and how to assure it", Quality Assurance in Education Year: 1998 Volume: 6 Issue: 1 Page: 28 – 36.

16. K. W. M. Siu, "Evaluating technical education in is spatially and temporally compressed world", Engineering Science and Education Journal, August 1998.

17. Jan McKay and David Kember, "Quality assurance systems and educational development: part 2 – the need for complementary staff development", Quality Assurance in Education Volume 7. Number 3. 1999. pp. 164–168 # MCB University Press. ISSN 0968-4883.

18. Dr Bernardo F Adiviso, "Total Quality Management (TQM): Managing Technical and Vocational Education through Change".

19. Haji Zakaria bin Yahya, "Vocational and Technical Education and Training (VTET) Systems of SEAMEO Member, Countries: Meeting the Challenges of the Year 2000 and Beyond".

20. Haji Mohd Daud Bin Haji Mahmud. "The Teachers of the Technological Age".

21. Gulser Koksal and Alpay Egitman, "Planning and Design of Industrial Engineering Education Quality", Computers ind. Eng. Vol. 35, No. 3, pp. 639-642, 1998 Elsevier Science Ltd.

22. Karapetrovic, S., Rajamani, D. 1998. "An Approach to the application of statistical Quality Control Techniques in Engineering Courses." Journals of Engineering Education 82(2): 269-276.

23. Bester field-Scare, M., Amaya, N.Y., Shuman. L. J., Atman, C.J implication of statistical process Monitoring for ABET2000 Program Evaluation: An Example Using Freshmen Engineering Attitudes, American Society for Engineering Education Conference proceedings, Seattle W .A, June 1998.

24. K. Grygoryev and Karapetrovic, S. Tracking Classroom Teaching and Learning: An SPC Application, Quality Engineering, 17: 405-418, 2005.

25. Jill Johnes, “Measuring teaching efficiency in higher education: An application of data envelopment analysis to economics graduates from UK Universities 1993”, European Journal of Operational Research 174 (2006) 443–456.

26. F. Craig Johnson and William A.J. Golomski, “Quality concepts in education”, The TQM Magazine Volume 11. Number 6. 1999. pp. 467–473.

27. Muhammad Z Mamun, “Total Quality Management of the non-government universities in Bangladesh”, 0-7803-6652-2/2000/$10.0002000 IEEE.

28. Chandandeep Singh and Kuldeep Sareen, “Application of DEMING’S PHILOSPHY to improve the quality of technical education”.

29. Manpreet Kaur, Chandandeep Singh, and Kuldeep Kumar Sareen, “Improving Quality of Technical Education using ISO 9001:2000”.

30. Sangeeta Sahney, Devinder Kumar Banwet and Sabita Karunes, “Enhancing Quality in Education- application of QFD- an Industry Perspective”.

31. Angelo Tartaglia and Elena Tresso (2004), “An Automatic Evaluation System for Technical Education at the University Level”, 0018-9359/02$17.00 © 2002 IEEE.

32. XJAO-WA LI, JIAN-HUA ZHAO, BAO-HONG LI,” Investigation of Fuzzy Mathematical Model for General Evaluation of Administrators in University”, Proceedings of the Third International Conference on Machine Learning and Cyhemedcs, Shanghai, 26-29 August 2004.

33. Donev, V.S. and Barudov, “Quality management at the Technical University of Varna - approaches and impact”, Information Technology Based Higher Education and Training, 2004. ITHET 2004. Proceedings of the Fifth International Conference on Publication Date: 31 May-2 June 2004.

34. Augustus E. Osseo-Asare, David Longbottom and William D. Murphy, “Leadership best practices for sustaining quality in UK higher education from the perspective of the EFQM Excellence Model”, Quality Assurance in Education Vol. 13 No. 2, 2005 pp. 148-170.,

35. Cecilia Temponi, "Continuous improvement framework: implications for academia", Emerald Group, Quality Assurance in Education Vol. 13 No. 1, 2005.

36. Jitesh Thakkar, Anil Shastree and S.G. Deshmukh, "Total quality management (TQM) in self-financed technical institutions", Quality Assurance in Education Volume: 14 Number: 1 Year: 2006 pp: 54-74.

37. Thomas F. Edgar, Babatunde A. Ogunnaike, James J. Downs, Kenneth R. Muske and B. Wayne Bequette, "Renovating the undergraduate process control course", Computers and Chemical Engineering 30 (2006) 1749–1762.

38. Roediger Voss and Thorsten Gruber, "The desired teaching qualities of lecturers in higher education: a means end analysis", Quality Assurance in Education Vol. 14 No. 3, 2006 pp. 217-242

39. S. S. Mahapatra and M. S. Khan, "A framework for analyzing quality in education settings", European Journal of Engineering Education Vol. 32, No. 2, May 2007, 205–217.

40. Yau Tsai and Sue Beverton, "Top-down management: an effective tool in higher education?", International Journal of Educational Management Vol. 21 No. 1, 2007 pp. 6-16.

41. Hartini Ahmad, Arthur Francis and Mohamed Zairi, "Business process reengineering: critical success factors in higher education", Emerald Group, Business Process Management Journal Vol. 13 No. 3, 2007 pp. 451-469.

42. S. S. Mahapatra and M. S. Khan, "A neural network approach for assessing quality in technical education: an empirical study", International Journal of Productivity and Quality Management 2007, Vol.2, No.3.

43. Dr. Subrata Das, Dr. Anindya Ghosh, "Quality assurance in textile education"

44. Gitachari Srikanthan and John F. Dalrymple, "A conceptual overview of a holistic model for quality in higher education", Emerald Group, International Journal of Educational Management Vol. 21 No.3, 2007.

45. Yousif Bahzad and Zahir Irani, "Developing a Quality Assurance Model for Small Military Institutions", European and Mediterranean Conference on Information Systems 2008 (EMCIS2008) May 25-26 2008.

46. C.M. Gheorghe, D. Constantinescu and M. Covrig, "The Determination of Factors Underlying Decision Making Process on Quality Improvement in Technical Education", IEEE 2008.

47. Ziren Wang and Ronghua Liang, "Discuss on Applying SPC to Quality Management in University Education", The 9th International Conference for Young Computer Scientists, IEEE, 2008

48. Prof. dr. eng. Lidia Cristea and Lecturer dr. eng. Dan Gogoncea, "Fuzzy Approach in Quality Management of Higher Education", The 9th International Conference for Young Computer Scientists, IEEE, 2008.

49. C. M. Bhatia and Smita Bhatia, "An Integrated Approach for Restructuring Higher Technical Education".

50. Hafiz Muhammad Inamullah, M. Naseeruddin and Ishtiaq Hussain, "The Development of Technical Education In Pakistan", International Business & Economics Research Journal – January 2009 Volume 8, Number 1.

51. Bakare, C.C. 1975. "Some Psychological Correlates of Academic Success and Failure". African Journal of Educational Research. 2.

52. Lage, M. and Tregelia, M. 1996. "The Impact of Integrating Scholarship on Women into Introductory Economics: Evidence from One Institution". Journal of Economic Education. 27:26-36.

53. Dynan, K. and Rouse, C. 1997. "The Under Utilization Of Women In Economics: A Study.

54. Anderson, G., Benjamin, D., and Fuss, M. 1994. "The Determinant Of Success In University.

55. Muhammad Z Mamun, "TQM of the non-govt. universities in Bangladesh", ICMIT 2000.

56. Satty, (1977, 1980) T.L, "The Analytical Hierarchy Process".

57. Hertz, J.K. 1991. Introduction to the Theory of Neural Computation. Addison – Wesley: New York, NY.

58. Adefowoju, B.S. and Osofisan A.O. 2004. "Cocoa Production Forecasting Using Artificial Neural Network".

59. Zadeh, L., 1965. Fuzzy sets, Information Control 8, 338–353.

60. Van Laarhoven, P.J.M., Pedrycz, W., 1983. A fuzzy extension of Saaty's priority theory. Fuzzy Sets and Systems 11,229–241.

61. Kahraman, C., Ulukan, Z., Tolga, E., 1998. A fuzzy weighted evaluation method using objective and subjective measures. In: Proceedings of the International ICSC Symposium on Engineering of Intelligent Systems (EIS'98), Vol. 1, University Laguna Tenerife, Spain, pp. 57–63.

62. Deng, H., 1999. Multicriteria analysis with fuzzy pairwise comparison. International Journal of Approximate Reasoning21 (3), 215–231.

63. Lee, M., Pham, H., Zhang, X., 1999. A methodology for priority setting with application to software development process. European Journal of Operation al Research 118,375–389.

64. Cheng, C.-H., Yang, K.-L., Hwang, C.-L., 1999. Evaluating attack helicopters by AHP based on linguistic variable weight. European Journal of Operation al Research 116 (2), 423–435.

65. Zhu, K.-J., Jing, Y., Chang, D.-Y., 1999. A discussion of extent analysis method and applications of fuzzy AHP. European Journal of Operational Research 116, 450–456.

66. Cengiz Kahraman, Ufuk Cebeci, Da Ruan, 2003, "Multi-attribute comparison of catering service companies using fuzzy AHP: The case of Turkey", Int. J. Production Economics 87 (2004) 171–184.

67. Da-Yong Chang, (1996), "Applications of the extent analysis method on fuzzy AHP", European Journal of Operational Research 95 (1996) 649-655.

68. Cheng, C.-H., 1997. Evaluating naval tactical missile systems by fuzzy AHP based on the grade value of membership function. European Journal of Operational Research 96 (2), 343–350.

69. Weck, M., Klocke, F., Schell, H., Ruenauver, E., 1997. Evaluating alternative production cycles using the extended fuzzy AHP method. European Journal of Operational Research 100 (2), 351–366.

70. Chang, D.-Y., 1992. Extent Analysis and Synthetic Decision, Optimization Techniques and Applications, Vol. 1. World Scientific, Singapore, p. 352.

71. Chang, D.-Y., 1996. Applications of the extent analysis method on fuzzy AHP. European Journal of Operational Research 95, 649–655.

72. P. Tsvetinov, L. Mikhailov, Reasoning Under Uncertainty during Pre-negotiations Using a Fuzzy AHP, 2004. Available at http://www.expertguide.qut.com/guide/expert-details.jsp.

73. Buckley, J.J., 1985. Fuzzy Analytical hierarchical analysis. Fuzzy Sets and Systems 17, 233–247.

74. Stam, A., Minghe, S., Haines, M., 1996. Artificial neural network representations for hierarchical preference structures. Computers and Operations Research 23 (12), 1191–1201.

75. Cheng, C.-H., 1997. Evaluating naval tactical missile systems by fuzzy AHP based on the grade value of membership function. European Journal of Operational Research 96 (2), 343–350.

76. Weck, M., Klocke, F., Schell, H., Ruenauver, E., 1997. Evaluating alternative production cycles using the extended fuzzy AHP method. European Journal of Operational Research 100 (2), 351–366.

77. Chan, F.T.S., Chan, M.H., Tang, N.K.H., 2000a. Evaluation methodologies for technology selection. Journal of Materials Processing Technology 107, 330–337.

78. Chan, F.T.S., Jiang, B., Tang, N.K.H., 2000b. The development of intelligent decision support tools to aid the design of flexible manufacturing systems. International Journal of Production Economics 65 (1), 73–84.

79. Leung, L.C., Cao, D., 2000. On consistency and ranking of alternatives in fuzzy AHP. European Journal of Operational Research 124, 102–113.

80. Kuo, R.J., Chi, S.C., Kao, S.S., 2002. A decision support system for selecting convenience store location through integration of fuzzy AHP and artificial neural network. Computers in Industry 47 (2), 199–214.

81. Sage, A.P. (1977), Interpretive Structural Modeling: Methodology for Large-scale Systems, McGraw-Hill, New York, NY, pp. 91-164.

82. Jharkharia, S. and Shankar, R. (2004), "IT enablement of supply chains: modeling the enablers", International Journal of Productivity and Performance Management, Vol. 53 No. 8, pp. 700-12.

83. Faisal, M.N., Banwet, D.K., and Shankar, R. (2006), "Supply chain risk mitigation: modeling the enablers", Business Process Management Journal Vol. 12 No. 4, pp. 535-552.

84. Singh R.K., Garg S., Deshmukh S.G., and Kumar M. (2007b), "modeling of critical success factor for implementation of AMTs", Journal of modeling in management, vol. 2, no. 3, pp. 232-250.

85. Singh R.K., Garg S.K., and Deshmukh S.G., (2007a) "Interpretive structural modelling of factors for improving competitiveness of SMEs", International journal of productivity and quality management, vol. 2, No. 4, pp 423-440.

86. Charan, P., Shankar, R., and Baisya, R. K. (2008), "Analysis of interactions among the variables of supply chain performance measurement system implementation", Business Process Management Journal Vol. 14 No. 4, 2008 pp. 512-529.

87. Pandey V.C., and Garg S. (2009), "Analysis of interaction among the enablers of agility in supply chain", Journal of Advances in Management Research Vol. 6 No. 1, pp. 99-114.

88. Miller, D. (1993, August). Total quality management and the curriculum audit seminar. Paper presented at the National Academy of School Administrators (1 Workshop, American Association of School Administrators, Gurnee. IL.

89. Bell, R E & light, M (1993) Open Universities: A British tradition? The Society for Research into Higher Education & Open University Press, Buckingham._Journal on ISTE Volume 30(2007).

90. Achintya "Technical Education Scenario and TQM Matrix." Proceedings of the 19th Indian Engineering Congress and National Seminar on 'Destination 2020 — India: A Developed Nation,' the Institution of Engineers (India), Maharashtra State Centre, Mumbai, December 17-19, 2004, pp. 299-301.

91. Singh, D.K., "Synergism between Hospitality Education and Industry — Some Recommendations." Proceedings of the National Seminar on 'Technical Manpower Planning in India — Issues and Concerns,' J.N.T.U., Hyderabad, Proc. Vol. III (Human Resource Planning, eth by Sudhir K. Reddy), September 5-7, 2004, pp. 205-222.

92. Sinha, K.K., Singh, N.N. and Sinha, A.R., "Welfare Technology." Samiksha Prakashan, J.K. Market, Chhoti Kalyafli, Muzaffarpur, Edition, 2005. Achintya and Prabha, M., "Education Excellence through Total Quality Management." The Indian Journal of Technical Education, Vol. 28, No. 4, October — December 2005, pp. 43-48.

93. Chang I.F. (1998) Challenges to engineering education in twenty-first century, Westchester graduate centre, Hawthorne, New York.

94. Levy Frank and Murnane, Richard J. (2004) The new division of labor and how computers are creating the next job market, New Jersey, Princeton University Press,

95. Freeman Richard B. (2005) Does globalization of scientific and engineering workforce threaten US economy leadership, Working paper No-11457, Cambridge, National Bureau of economic research (NBER)

96. Friedman, Thomas (2005). The world is flat and a brief history of globalize world in the 21st century, Penguin, London

97. Jones Russel C (2005) Are current engineering graduates in US being treated as commodities by employers http:// www.worldexpertise.com/are current engineering graduate.htm.

98. Ashoke Chandra, "Building a Good Institution", Journal of Engineering Education {75^{th} Issue}, Jan' 2006

99. Arun V. Parwate & Atul Jothi, "Changing Scenario of Technical Education", Journal of Engineering Education {71st Issue}, Jan' 2005.

100. A.Velumani & K. Ganesan, "Industrial Training in Engineering Curriculum", Journal of Engineering Education {71st Issue}, Jan' 2005

101. I.P.S. Ahuja & Tarun Nanda, "An Insight into Low Growth of Technical Education in India", The Indian Journal of Technical Education, Vol. 26, No. 3, JulySept'2003.

102. K.B.M. Nambudripad, “On Designing a Curriculum for Undergraduate Engineering Degree “, The Indian Journal of Technical Education, Vol. 26 No.3, JulySept’2003

103. Mamta Agarwal, “Examination Reform Initiatives in India“, Journal of Indian Education, Vol. XXXI, No. 1, May’2005.

104. M.C. Candramouly & M. Padmaja, “Quality in Technical Education A Critical Analysis of Governing Factors“, The Indian Journal of Technical Education, Vol. 26, No. 3, July –Sept.’ 2003

105. N.T. Khobragade, “Implementation of TQM in Engineering Education“, Journal of Engineering Education {72nd Issue}, April’ 2005

106. Niklas Jonsson, “Quality Assurance of Higher Educational Services {Case Study of California State University}”, Bachelor’s Thesis, 2004.

107. R.Hariharan, “Quality System for Technical Education in India”, The Indian Journal of Technical Education, Vol. 26, No. 2, April June’ 2003.

108. Rustom N. Sadri “Does our Examination System Need Reform?”, University News, 38{32}, August ‘ 2000.

109. P.Mohanty & R.R. Lakhe, “TQM in Service Sector “, Jaico Publishing House, 2002.

110. N. Gupchup, “Towards Quality Engineering Education – Indian Perspective and Global Context”, Journal of Engineering Education {72nd Issue}, April’ 2005

111. M.S. Bazaraa, H.D. Sherali, and C.M. Shetty, *Nonlinear Programming*, John Wiley & Sons, 2nd edition, 1993

112. H. Bersini, and V. Gorrini, “An Empirical Analysis of one type of Direct Adaptive Fuzzy Control,” *Fuzzy Logic and Intelligent Systems*, H. Li, and M. Gupta, Editors, Chapter 11, 289-309, Kluwer

113. H. Bersini, and G. Bontempi, “Now Comes the Time to Defuzzify Neuro-Fuzzy Models,” *Fuzzy Sets and Systems*, 90, 161-169, 1997

114. J.C. Bezdek, “Editorial: Fuzzy Models − What Are They, and Why?,” *IEEE Transactions on Fuzzy Systems*, 1(1), February 1993. Eklund, and J. Zhou, "Comparison of Learning Strategies for Adaptation of Fuzzy Controller Parameters," *Fuzzy Sets and Systems*, 106, 321-333, 1999

115. P.Y. Glorennec, "Learning Algorithms for Neuro-Fuzzy Networks," *Fuzzy Control Systems*, A. Kandel, and G. Langholz, Editors, pp. 4-18, CRC Press, Boca Raton,FL, 1994

116. D. Gorse, A.J. Shepherd, and J.G. Taylor, "The new ERA in Supervised Learning," *Neural Networks*, 10(2), 343-352, 1997

117. F. Guely, and P. Siarry, "Gradient Descent Method for Optimizing Various Fuzzy Rule Bases," *Proceedings of the second IEEE Conference on Fuzzy Systems*, 1241-1246, 1993

118. Guely, R. La, and P. Siarry, "Fuzzy Rule Base Learning Through Simulated Annealing," *Fuzzy Sets and Systems*, 105, 353-363, 1999

119. H.B. Gurocak, "A Genetic-Algorithm-Based Method for Tuning Fuzzy Logic Controllers," *Fuzzy Sets and Systems*, 108, 39-47, 1999

120. I. Hayashi, H. Nomura, and N. Wakami, "Acquisition of Inference Rules by Neural Network Driven Fuzzy Reasoning," *Japanese Journal of Fuzzy Theory and Systems*, 2(4), 453-469, 1990.

121. K. Navaneethakrishnan, The Indian Journal of Technical Education, Volume 32. No-4, October – December- 2009, Page 65-67

122. Annual Technical Manpower Review, Delhi-2006, Page- 19-25

123. Annual Technical Manpower Review,Delhi-2007, Page- 37-40

124. India Today, September- 2009 Edition, Page -37-38

125. Quant Network Ranking of Financial Engineering (MFE), Mathematical Finance MS Programme, New York, Sept 25, 2009

126. V. Kumara Swamy, The Telegraph, Calcutta, India, Thursday, June 11, 2009, Front Page

127. Kathryn M. O'Neill, News Office, U.S. News, August 19, 2005, Front Page

128. India Today, September, 2010

129. Nanopolitan, Prathap and Gupta's paper on the research output from India's engineering institution, Sunday, August 09, 2009

130. Academic Ranking of World University (ARWU) Ranking Methodology 2010

131. http://www.dce.edu

132. http://hsonline.worldpress.com

133. http://nsit.ac.in

134. http://jmi.nic.in

135. http://ipu.ac.in

136. http://bvcoend.ac.in

137. Training and Placement Department, FOT, Delhi.

138. Divya et al 2010 "Project : Soft Computing technique" A practical approach.

Appendices

Questionnaire for Expert Opinion

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	9
	Expertise in subjects and well-organized lectures	9
	Good communication skill of academic staff	8
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	8
	Encouragement for sports, games and cultural activities	8
	Cleanliness, orderliness, systematic and methodical	7
	Available regularly for students' consultation	9
	Effective classroom management	6
	Recognition of the students	7
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	8
	Expertise in subjects and well-organized lectures	10
	Good communication skill of academic staff	8
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	9
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	7
	Available regularly for students' consultation	9
	Effective classroom management	10
	Recognition of the students	8
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	8
	Expertise in subjects and well-organized lectures	10
	Good communication skill of academic staff	8
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	9
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	7
	Available regularly for students' consultation	9
	Effective classroom management	10
	Recognition of the students	8
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	9
	Comprehensive learning resources	8
	Opportunities for campus training & placement	10
	Close supervision of students' work	10
	Expertise in subjects and well-organized lectures	10
	Good communication skill of academic staff	10
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	10
	Encouragement for sports, games and cultural activities	8
	Cleanliness, orderliness, systematic and methodical	8
	Available regularly for students' consultation	7
	Effective classroom management	7
	Recognition of the students	9
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	9
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	10
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	7
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	6
	Available regularly for students' consultation	6
	Effective classroom management	6
	Recognition of the students	7
	Adaptability to modern techniques	10

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	6
	Comprehensive learning resources	5
	Opportunities for campus training & placement	3
	Close supervision of students' work	7
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	8
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	6
	Encouragement for sports, games and cultural activities	2
	Cleanliness, orderliness, systematic and methodical	3
	Available regularly for students' consultation	3
	Effective classroom management	5
	Recognition of the students	2
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	4
	Opportunities for campus training & placement	6
	Close supervision of students' work	5
	Expertise in subjects and well-organized lectures	8
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	4
	Encouragement for sports, games and cultural activities	3
	Cleanliness, orderliness, systematic and methodical	2
	Available regularly for students' consultation	3
	Effective classroom management	4
	Recognition of the students	6
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	9
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	7
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	7
	Encouragement for sports, games and cultural activities	6
	Cleanliness, orderliness, systematic and methodical	5
	Available regularly for students' consultation	5
	Effective classroom management	5
	Recognition of the students	6
	Adaptability to modern techniques	7

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	7
	Opportunities for campus training & placement	9
	Close supervision of students' work	9
	Expertise in subjects and well-organized lectures	10
	Good communication skill of academic staff	9
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	9
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	9
	Available regularly for students' consultation	8
	Effective classroom management	8
	Recognition of the students	8
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	8
	Expertise in subjects and well-organized lectures	10
	Good communication skill of academic staff	8
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	9
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	7
	Available regularly for students' consultation	9
	Effective classroom management	10
	Recognition of the students	8
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	8
	Expertise in subjects and well-organized lectures	10
	Good communication skill of academic staff	8
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	9
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	7
	Available regularly for students' consultation	9
	Effective classroom management	10
	Recognition of the students	8
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	8
	Expertise in subjects and well-organized lectures	10
	Good communication skill of academic staff	8
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	9
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	7
	Available regularly for students' consultation	9
	Effective classroom management	10
	Recognition of the students	8
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	9
	Comprehensive learning resources	8
	Opportunities for campus training & placement	10
	Close supervision of students' work	10
	Expertise in subjects and well-organized lectures	10
	Good communication skill of academic staff	10
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	10
	Encouragement for sports, games and cultural activities	8
	Cleanliness, orderliness, systematic and methodical	8
	Available regularly for students' consultation	7
	Effective classroom management	7
	Recognition of the students	9
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	9
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	10
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	7
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	6
	Available regularly for students' consultation	6
	Effective classroom management	6
	Recognition of the students	7
	Adaptability to modern techniques	10

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	9
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	10
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	7
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	6
	Available regularly for students' consultation	6
	Effective classroom management	6
	Recognition of the students	7
	Adaptability to modern techniques	10

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	6
	Comprehensive learning resources	5
	Opportunities for campus training & placement	3
	Close supervision of students' work	7
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	8
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	6
	Encouragement for sports, games and cultural activities	2
	Cleanliness, orderliness, systematic and methodical	3
	Available regularly for students' consultation	3
	Effective classroom management	5
	Recognition of the students	2
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	4
	Opportunities for campus training & placement	6
	Close supervision of students' work	5
	Expertise in subjects and well-organized lectures	8
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	4
	Encouragement for sports, games and cultural activities	3
	Cleanliness, orderliness, systematic and methodical	2
	Available regularly for students' consultation	3
	Effective classroom management	4
	Recognition of the students	6
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	8
	Comprehensive learning resources	4
	Opportunities for campus training & placement	6
	Close supervision of students' work	5
	Expertise in subjects and well-organized lectures	8
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	4
	Encouragement for sports, games and cultural activities	3
	Cleanliness, orderliness, systematic and methodical	2
	Available regularly for students' consultation	3
	Effective classroom management	4
	Recognition of the students	6
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	9
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	7
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	7
	Encouragement for sports, games and cultural activities	6
	Cleanliness, orderliness, systematic and methodical	5
	Available regularly for students' consultation	5
	Effective classroom management	5
	Recognition of the students	6
	Adaptability to modern techniques	7

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	9
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	10
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	7
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	6
	Available regularly for students' consultation	6
	Effective classroom management	6
	Recognition of the students	7
	Adaptability to modern techniques	10

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	6
	Comprehensive learning resources	5
	Opportunities for campus training & placement	3
	Close supervision of students' work	7
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	8
	Well-equipped laboratories with modern facilities	9
	Design of course structure based on job requirements	6
	Encouragement for sports, games and cultural activities	2
	Cleanliness, orderliness, systematic and methodical	3
	Available regularly for students' consultation	3
	Effective classroom management	5
	Recognition of the students	2
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
	Training on state-of-the-art technology	8
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	9
	Expertise in subjects and well-organized lectures	9
	Good communication skill of academic staff	8
Improvement in technical education system	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	8
	Encouragement for sports, games and cultural activities	8
	Cleanliness, orderliness, systematic and methodical	7
	Available regularly for students' consultation	9
	Effective classroom management	6
	Recognition of the students	7
	Adaptability to modern techniques	9

	FACTORS	RANGE (0-10)
Improvement in technical education system	Training on state-of-the-art technology	9
	Comprehensive learning resources	9
	Opportunities for campus training & placement	10
	Close supervision of students' work	10
	Expertise in subjects and well-organized lectures	7
	Good communication skill of academic staff	7
	Well-equipped laboratories with modern facilities	10
	Design of course structure based on job requirements	7
	Encouragement for sports, games and cultural activities	7
	Cleanliness, orderliness, systematic and methodical	6
	Available regularly for students' consultation	6
	Effective classroom management	6
	Recognition of the students	7
	Adaptability to modern techniques	10

Questionnaire for Fuzzy AHP

It was a Pair-Wise Comparison Matrix type questionnaire. The rating has was done according to the scale shown in Table below.

Importance (or preference) of one attribute over another		
Absolutely Important	(7/2, 4, 9/2)	A
Very Strongly Important	(5/2, 3, 7/2)	B
Fairly Strongly important	(3/2, 2, 5/2)	C
Weakly important	(2/3, 1, 3/2)	D
Equally important	(1, 1, 1)	E

Reply No. 1

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	B	C	D
Student Quality (SQ)	-------	(1,1,1)	B	C
Management Inputs (MI)	-------	--------	(1,1,1)	A
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	B	D	B
Qualification of Faculty (Qua)	-------	(1,1,1)	C	E
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	D
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	B	C
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	C	B	E
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	B	C
Library Standards (LS)	-------	--------	(1,1,1)	D	B
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	E
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	A	B	C
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	C	D
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	B
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 2

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	E	A	B
Student Quality (SQ)	-------	(1,1,1)	C	B
Management Inputs (MI)	-------	--------	(1,1,1)	A
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	D	C	C
Qualification of Faculty (Qua)	-------	(1,1,1)	A	C
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	D
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

<u>Matrix no. 3</u>

<u>Sub-Attributes of Students Quality pair wise comparison matrix</u>

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	C	B
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	B	D	A	E
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	A	B	B
Library Standards (LS)	-------	--------	(1,1,1)	D	C
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	E
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	E	A	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	B	C
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 3

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	B	E	B
Student Quality (SQ)	-------	(1,1,1)	B	A
Management Inputs (MI)	-------	--------	(1,1,1)	B
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	D	C	B
Qualification of Faculty (Qua)	-------	(1,1,1)	A	E
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	D
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

<u>Matrix no. 3</u>

<u>Sub-Attributes of Students Quality pair wise comparison matrix</u>

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	C	A
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	B	E
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	A	C	B
Library Standards (LS)	-------	--------	(1,1,1)	D	C
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	E
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WELC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	E	B	D
Well – Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	C
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	E
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 4

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	D	C
Student Quality (SQ)	-------	(1,1,1)	B	A
Management Inputs (MI)	-------	--------	(1,1,1)	E
Infrastructure (IF)	--------	--------	--------	(1,1,1)

<u>Matrix no. 2</u>

<u>Sub-Attributes of Faculty Quality pair wise comparison matrix</u>

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	D	C	B
Qualification of Faculty (Qua)	-------	(1,1,1)	A	E
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	D
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	B	A
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	C	E
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	B	E	D
Library Standards (LS)	-------	--------	(1,1,1)	D	C
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	B
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	E	A	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	B
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	E
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No.5

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	D	C
Student Quality (SQ)	-------	(1,1,1)	B	A
Management Inputs (MI)	-------	--------	(1,1,1)	E
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	D	C	B
Qualification of Faculty (Qua)	-------	(1,1,1)	A	E
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	D
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	B	A
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

<u>Matrix no. 4</u>

<u>Sub-Attributes of Management Inputs pair wise comparison matrix</u>

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	C	E
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	B	E	A
Library Standards (LS)	-------	--------	(1,1,1)	D	C
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	B
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	E	B	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	C	B
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	E
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No.6

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	D	C
Student Quality (SQ)	-------	(1,1,1)	E	A
Management Inputs (MI)	-------	--------	(1,1,1)	D
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	B	C	B
Qualification of Faculty (Qua)	-------	(1,1,1)	A	E
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	D
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	B	C
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	C	E
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	E	A
Library Standards (LS)	-------	--------	(1,1,1)	D	C
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	B
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	E	B	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	C	B
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	E
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 7

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	B	C
Student Quality (SQ)	-------	(1,1,1)	E	A
Management Inputs (MI)	-------	--------	(1,1,1)	D
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	E	C	A
Qualification of Faculty (Qua)	-------	(1,1,1)	A	E
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	D
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	A	C
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	B	C	D
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	E	A
Library Standards (LS)	-------	--------	(1,1,1)	D	C
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	B
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	D	B	E
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	B
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 8

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	B	E	C
Student Quality (SQ)	-------	(1,1,1)	A	B
Management Inputs (MI)	-------	--------	(1,1,1)	D
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	E	B	A
Qualification of Faculty (Qua)	-------	(1,1,1)	A	E
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	C
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	A	B
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	B	E	C
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	D	B
Library Standards (LS)	-------	--------	(1,1,1)	E	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	B
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	D	B	E
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	B
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	E
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 9

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	B	E	C
Student Quality (SQ)	-------	(1,1,1)	D	B
Management Inputs (MI)	-------	--------	(1,1,1)	E
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	C	B	C
Qualification of Faculty (Qua)	-------	(1,1,1)	A	E
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	C
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	A	B
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	B	C	A
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	E	B
Library Standards (LS)	-------	--------	(1,1,1)	D	E
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	B
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WELC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	D	C	E
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	B
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	E
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 10

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	B	E	C
Student Quality (SQ)	-------	(1,1,1)	D	B
Management Inputs (MI)	-------	--------	(1,1,1)	E
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	C	B	C
Qualification of Faculty (Qua)	-------	(1,1,1)	A	E
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	C
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	A	B
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	C	A
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	E	B
Library Standards (LS)	-------	--------	(1,1,1)	D	E
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	B
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WELC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	D	C	E
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	B
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	E
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

<u>Reply No. 11</u>

<u>Matrix no. 1</u>

<u>Quality Control Main Attributes pair wise comparison matrix</u>

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	B	E	C
Student Quality (SQ)	-------	(1,1,1)	D	B
Management Inputs (MI)	-------	--------	(1,1,1)	E
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	C	E	B
Qualification of Faculty (Qua)	-------	(1,1,1)	A	D
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	C
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	E	B
Attitude towards learning (ATL)	-------	(1,1,1)	C
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	C	A
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	E	B
Library Standards (LS)	-------	--------	(1,1,1)	C	E
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	B
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	D	B	E
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	B
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 12

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	E	C
Student Quality (SQ)	-------	(1,1,1)	D	B
Management Inputs (MI)	-------	--------	(1,1,1)	E
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	C	E	C
Qualification of Faculty (Qua)	-------	(1,1,1)	B	D
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	E
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	E	B
Attitude towards learning (ATL)	-------	(1,1,1)	C
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	C	A
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	E	B
Library Standards (LS)	-------	--------	(1,1,1)	B	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	E
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	E	B	A
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	C
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 13

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	D	C
Student Quality (SQ)	-------	(1,1,1)	E	B
Management Inputs (MI)	-------	--------	(1,1,1)	D
Infrastructure (IF)	--------	--------	--------	(1,1,1)

<u>Matrix no. 2</u>

<u>Sub-Attributes of Faculty Quality pair wise comparison matrix</u>

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	D	E	C
Qualification of Faculty (Qua)	-------	(1,1,1)	A	B
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	E
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	A	B
Attitude towards learning (ATL)	-------	(1,1,1)	D
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	C	A
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	E	B
Library Standards (LS)	-------	--------	(1,1,1)	A	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	E
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	E	B	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	C
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No.14

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	D	C
Student Quality (SQ)	-------	(1,1,1)	E	B
Management Inputs (MI)	-------	--------	(1,1,1)	D
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	E	D	C
Qualification of Faculty (Qua)	-------	(1,1,1)	A	B
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	C
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	A	C
Attitude towards learning (ATL)	-------	(1,1,1)	D
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	C	A
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	A	B
Library Standards (LS)	-------	--------	(1,1,1)	E	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	C
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	E	C	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	B
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 15

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	D	C
Student Quality (SQ)	-------	(1,1,1)	E	B
Management Inputs (MI)	-------	--------	(1,1,1)	D
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	E	D	C
Qualification of Faculty (Qua)	-------	(1,1,1)	A	D
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	B
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	A	C
Attitude towards learning (ATL)	-------	(1,1,1)	D
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

<u>Matrix no. 4</u>

<u>Sub-Attributes of Management Inputs pair wise comparison matrix</u>

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	D	C	A
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	A	B
Library Standards (LS)	-------	--------	(1,1,1)	E	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	C
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	E	C	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	A	E
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 16

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	D	C
Student Quality (SQ)	-------	(1,1,1)	E	B
Management Inputs (MI)	-------	--------	(1,1,1)	D
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	E	D	C
Qualification of Faculty (Qua)	-------	(1,1,1)	A	D
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	B
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	A	E
Attitude towards learning (ATL)	-------	(1,1,1)	D
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	B	C	E
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	D	A	B
Library Standards (LS)	-------	--------	(1,1,1)	E	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	C
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	A	C	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	D	E
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 17

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	B	C
Student Quality (SQ)	-------	(1,1,1)	E	A
Management Inputs (MI)	-------	--------	(1,1,1)	D
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	B	D	E
Qualification of Faculty (Qua)	-------	(1,1,1)	A	D
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	C
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	A	E
Attitude towards learning (ATL)	-------	(1,1,1)	B
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	B	C	E
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	A	B
Library Standards (LS)	-------	--------	(1,1,1)	E	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	C
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	A	C	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	B	E
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 18

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	B	C
Student Quality (SQ)	-------	(1,1,1)	E	A
Management Inputs (MI)	-------	--------	(1,1,1)	D
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	B	C	E
Qualification of Faculty (Qua)	-------	(1,1,1)	A	D
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	C
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	D	E
Attitude towards learning (ATL)	-------	(1,1,1)	B
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	B	C	D
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	A	B
Library Standards (LS)	-------	--------	(1,1,1)	B	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	C
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	A	C	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	B	E
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	D
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 19

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	E	B	C
Student Quality (SQ)	-------	(1,1,1)	D	A
Management Inputs (MI)	-------	--------	(1,1,1)	B
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	B	C	E
Qualification of Faculty (Qua)	-------	(1,1,1)	D	A
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	C
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	B	E
Attitude towards learning (ATL)	-------	(1,1,1)	C
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	B	C	D
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	C	E	B
Library Standards (LS)	-------	--------	(1,1,1)	B	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	C
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	A	C	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	B	E
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	A
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 20

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	E	C
Student Quality (SQ)	-------	(1,1,1)	D	A
Management Inputs (MI)	-------	--------	(1,1,1)	B
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	B	D	E
Qualification of Faculty (Qua)	-------	(1,1,1)	C	A
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	E
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	E	A
Attitude towards learning (ATL)	-------	(1,1,1)	C
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	E	C	D
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	D	B	B
Library Standards (LS)	-------	--------	(1,1,1)	C	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	E
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	A	E	D
Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	B	A
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	E
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Reply No. 21

Matrix no. 1

Quality Control Main Attributes pair wise comparison matrix

Quality Control Main Attributes	Faculty Quality (FQ)	Student Quality (SQ)	Management Inputs (MI)	Infrastructure (IF)
Faculty Quality (FQ)	(1,1,1)	A	B	E
Student Quality (SQ)	-------	(1,1,1)	C	A
Management Inputs (MI)	-------	--------	(1,1,1)	B
Infrastructure (IF)	--------	--------	--------	(1,1,1)

Matrix no. 2

Sub-Attributes of Faculty Quality pair wise comparison matrix

Faculty Quality Sub- Attributes	Good Communication Skills of Faculty (GCS)	Qualification of Faculty (Qua)	Teaching and Industrial Experience (T&I Ex)	Expertise in Subject and Well-Organised Lectures (E S& WOL)
Good Communication Skills of Faculty (GCS)	(1,1,1)	B	D	E
Qualification of Faculty (Qua)	-------	(1,1,1)	A	B
Teaching and Industrial Experience (T&I Ex)	-------	--------	(1,1,1)	C
Expertise in Subject and Well-Organised Lectures (E S& WOL)	--------	--------	--------	(1,1,1)

Matrix no. 3

Sub-Attributes of Students Quality pair wise comparison matrix

Students Quality Sub- Attributes	Background and Merit of Entering Students (B & MES)	Attitude towards learning (ATL)	Time taken to complete the degree (TCD)
Background and Merit of Entering Students (B & MES)	(1,1,1)	D	A
Attitude towards learning (ATL)	-------	(1,1,1)	E
Time taken to complete the degree (TCD)	-------	--------	(1,1,1)

Matrix no. 4

Sub-Attributes of Management Inputs pair wise comparison matrix

Management Inputs Sub- Factors	Training for Faculty Development (TFD)	Curriculum Design {upgradation of course content} (CD)	Library Standards (LS)	Timely Assessment of Faculty and Students (TA F&S)	Training and Placement (T&P)
Training for Faculty Development (TFD)	(1,1,1)	A	E	C	D
Curriculum Design {upgradation of course content} (CD)	-------	(1,1,1)	D	A	B
Library Standards (LS)	-------	--------	(1,1,1)	C	D
Timely Assessment of Faculty and Students (TA F&S)	--------	--------	--------	(1,1,1)	B
Training and Placement (T&P)	--------	--------	--------	--------	(1,1,1)

Matrix no. 5

Sub-Attributes of Infrastructure pair wise comparison matrix

Infrastructure Sub- Factors	College Building and Premises (CBP)	Well –Equipped labs and Classrooms {Modern Technology} (WE LC)	Cleanliness, Orderliness, Systematic and Methodical (COSM)	Hostel and Mess Facility (HMF)
College Building and Premises (CBP)	(1,1,1)	A	E	D
Well – Equipped labs and Classrooms {Modern Technology} (WE LC)	-------	(1,1,1)	B	C
Cleanliness, Orderliness, Systematic and Methodical (COSM)	-------	--------	(1,1,1)	A
Hostel and Mess Facility (HMF)	--------	--------	--------	(1,1,1)

Details of Research Papers Published in International/National Journals

1. A.K. Madan and R.S. Mishra, 2009 "Forecasting the academic results of students using ANN: A case study of an engineering college" IJTE vol.32, no.4, PP-68-77 (ISSN 0971-3034).

2. A.K. Madan and R.S. Mishra, 2010 "Application of fuzzy AHP for Comparison of Engineering institutions: An expert approach". "International Journal of Applied Engineering research" vol-5 No. 21-22-, PP-3455-3467 (ISSN No. 0973-4562).

3. A.K. Madan and R.S. Mishra, 2011, "Application of Statistical Process Control for Quality management in technical education". "Global Journal of Finance and management" Vol.3 No.-1, PP-25-33 (ISSN No.0975-6477).

4. A.K. Madan and R.S. Mishra, 2011 Ranking of engineering colleges based on Statistical method and survey analysis to assess the quality in technical education. "International Journal of Applied Engineering research" PP-201-209, Vol.-6 No.-2 (ISSN No. 0973-4562).

5. A.K. Madan and R.S. Mishra, 2011 Analysis of variables for quality management in technical education using interpretive structural modeling "International Journal of Applied Engineering research" PP-211-219, Vol.-6 No.-2 (ISSN No. 0973-4562).

6. A.K. Madan et al. 2009 Prediction of quality in technical education using Fuzzy Logic. "Journal of Multidisciplinary Engg. Technologies" vol-4, No.-1 July-Dec PP19-28 (ISSN 0974-1771).

7. A.K. Madan et al 2009, A Fuzzy AHP approach for Assessing Quality in technical education. "Journal of Multidisciplinary Engg. Technologies", vol-4, No.-1 July-Dec, PP 34-45 (ISSN 0974-1771).

8. A.K. Madan and R.S. Mishra, 2011 Comparative study of Technical Institutions using Fuzzy Logic.to assess the quality in engineering institution "Global Journal of Finance and Economic management" Vol.1, No. 2, PP 95-108 (ISSN No.2249-3158).

"BIOGRAPHICAL PROFILE OF THE RESEARCHER"

1958 - Born in New Delhi, India, 15th April.

Academics

2011- Currently a candidate for the degree of Doctor of Philosophy in Production Engineering from University of Delhi, Delhi, India.

1981- Post Graduated from The City University, London, U.K

1979- Graduated from Delhi College of Engineering, University of Delhi, Delhi, India.

Experience (Appr-30 years)

- Joined Delhi College of Engineering, Delhi as a faculty in April 1991.
- Currently working as Associate Professor in the Department of Production and Industrial Engineering, DTU (formerly Delhi College of Engineering) Delhi.
- M/S Empire Industries LTD: January 1987- April 1991 (Asstt. Manager) Projects/ Products related to CAM/Automation etc.
- M/S K.G. Khosla Compressors L.T.D. Fbd.- June 1983 – January 1987 (Sr. Engr.) Projects/ Products related to CAM/Automation, Production Engineering., R&D etc.
- M/S GEC LTD, UK 1981-1983, Production Engg. Dealt with the projects/ products related to CNC Technology, APT, ASRS etc.

Publications

More than 25 publications in National / International Journals and conferences.

Affiliation/Membership

- Life Member, Indian Society of Technical Education, Delhi, India
- Have been Associate Member – Institution of Mechanical Engrs.

Address:

Ashok Kumar Madan

Associate Professor

Production Engineering Department,

DTU (formerly Delhi College of Engineering)

Delhi-110042, India

Quality Management

In

Technical Education

A thesis submitted to the Faculty of Technology, University of Delhi in the fulfillment of the requirements for the award of Degree of

DOCTOR OF PHILOSOPHY

In

Production Engineering

Submitted by

ASHOK KUMAR MADAN

Under the Supervision of

Prof. (DR) R.S. Mishra

Professor, Department of Mechanical Engineering,

Faculty of Technology, University of Delhi,

Delhi-110007

Department of Production Engineering

Faculty of Technology, University of Delhi, Delhi-110007 (INDIA)

2011

Chapter 6
Summary & Conclusions

Technical Education consists of three different stages: Educational Input, Educational process and learning outcome/output with feedback mechanism. The feedback coming from the output can be utilized to assess and improve the quality of TES. The main stakeholders of TES are Faculty, Students, Management and Infrastructure which are responsible for efficient functioning of Technical Education. There is a need of an effective quality management system in the education sector which can control, monitor and improve the quality of technical education. It also gives some of the important factors which should be considered for quality improvement in technical education.

The following conclusions have been drawn.

- The artificial neural network to enhance the effectiveness of a university admission system for improving the quality in Technical Education is quite useful. The model was developed based on some selected input variables from the pre admission data of five different sets of university graduates. It achieved an accuracy of over 73%, which shows the potential efficacy of Artificial Neural Network as a prediction tool and a selection criterion for candidates seeking admission into a university. One limitation of this model stems from the fact that not all the relevant performance influencing factors are obtainable from the pre-admission record forms filled by the students. A model incorporating the use of results from a carefully designed oral interview administered to the students may likely be an improvement over the present model. Also the extension of this model to non-engineering departments is recommended. The current admissions system should be reviewed in order to improve the standard of candidates being admitted into the institution. A more adequate ANN may be very useful for such an exercise.
- A model using Fuzzy logic and Matlab on the basis of expert opinions has been developed. This model can be used to evaluate the improvement in the quality in technical education by varying various factors. This model has been highly successful. Similar has been developed and used to predict the placement on the basis of data of the placements of the previous years. Actual results of the placements are very much in line with the predicted data on the basis of this model. Hence this model can be used successfully for the purpose of the placement in Technical Institution.
- A non traditional approach has been proposed to infer statistical and Fuzzy rules from quantitative database. Each factor was assigned with several fuzzy sets. Using fuzzy set concepts, fuzzy rules were inferred then Mat Lab Fuzzy logic tool box is used for

generating rules. Here we use only few parameters for analysis but this approach suggest that for large data base decision can be taken more effectively than traditional methodology with less mental fatigue. This method is just one of the many methods used to generate rules in an adaptive system. Though a simple are discussed here to know the system, it is important to realize how powerful this system is. Research is currently being made to use adaptive systems to model events in politics, history, medicine and even military planning. Consider the way the human beings learn. We all learn through experience and through experience we become smarter. Whether, it is the smell of lime, or the picture of our mother, we remember things as it is given to us. With memory, we improve on our actions or thoughts and by definition become smarter. Fuzzy logic can be applied the same way. Instead, of depending on humans to put specific fuzzy rules to deal with every situation, the machine should be able to produce its own rules through experience. This can be done with the Data in Rules. FL does not require precise inputs, but It uses an imprecise but very descriptive language to deal with input data more like a human operator. Fuzzy Logic provides a completely different, unorthodox way to approach a control problem. This method focuses on what the system should do rather than trying to understand how it works. One can concentrate on solving the problem rather than trying to model the system mathematically, if that is even possible. This almost invariably leads to quicker, cheaper solutions. Once understood, this technology is not difficult to apply and the results are usually quite surprising and pleasing.

➢ SPC is applied to analyze the result of second semester examination of all the streams held in MAY/JUNE-2009. The technique proves to be effective and the SPC control chart shows the problems occurring in the streams. The study shows that there is a need to investigate the PE stream as in both the control charts their values are crossing the control limits (LCL, UCL). There is a need to identify the following causes of the problems so that the quality can be improved.
  - Qualifications and merits of the student entry.
  - Faculty expertise
  - Adequacy of subject teacher
  - Effective classroom management
  - Faculty’s rapport with student and
  - Student’s understanding level

➢ A good quality TES is a major requirement for colleges and universities. Hence management should make sure that the TES should be constructed in the proper manner considering the important factors or attributes of technical education. Fuzzy AHP is an effective MCDM technique and can be used effectively for assessing quality in technical education. Since we are aware of the fact that in today's world, decisions are made in increasingly complex environments. Fuzzy decision making theory can be used for this purpose. This research concludes that Fuzzy AHP in an effective MCDM technique and can be applied to the education sector for assessing quality in technical education.

Among four Main Attributes, Faculty Quality is the most important, followed by Management Inputs, then Students Quality and in the end Infrastructure is the least important attribute among the four.

In terms of the Sub Attributes the very important Sub Attributes are (global weight >0.04) as follows: Good Communication Skills (GCS), Curriculum Design (CD), Qualification of Faculty (Qua), Timely Assessment of Faculty & Students (TA F& S), Teaching & Industrial Experience (T&I Ex), Training & Placement (T&P), Background & Merit of Entering Students (B&M ES), Well Equipped Labs and Classrooms (WE L&C), Attitude Towards Learning (ATL).

This methodology has also been used successfully to evaluate the priority weights. Ranking of Engineering is made on the basis of model "Priority Weight" and Statistical Method/Survey Analysis (using Fuzzy logic as soft computing technique).

- Interpretive structural modeling is a possible solution for modeling of various parameters to rank them as per criticality for improvement in quality of technical education. Interpretive structural modeling is useful for analyzing the effect of various factors on quality of Technical education that result in effective & precise decision making. This technique helps to develop a hierarchy model that includes the variable in order of their role for improving the quality of technical education. Driving power and dependence bring the related variable at common level. This technique works on the interrelationships among the variables.
- The ranking of the colleges is important in the university system since it indicates the scope of improvement of the institute. Analysis has been done to evaluate the area in which the improvement of the quality is required. Institutes having better quality of the faculty, placement of the students, Infrastructure and management inputs are found as higher in the ranking. Adopted methodology is quite useful in university system as well. However, certain modifications viz. interaction and collaboration of the programs with foreign universities is required. Ranking of colleges has been prepared on the basis of eight parameters. The Grade D college needs to improve their quality in technical education. There should be proper research activities and institution should enhance this activity on a wide spectrum. Comparative results are arranged in a tabular form for a better understanding of quality status of these institutes.

The work done shows the need of quality control in technical education and also illustrates its importance. Various techniques have been applied for assessing quality in technical education. All the techniques used show its effectiveness in achieving the desired goal.

SCOPE FOR FUTURE WORK:-

- Though an accuracy of 73% is achieved using ANN, further improvement may be possible with more relevant performance influencing factors obtainable from per admission record forms filled by the students.
- Factors with regards to performance of the students 1st semester to 8th semester can also be considered to prepare model for the placement using Fuzzy Matlab.
- Although experts from all parts of India participated in survey but majority of the expert were from north part of India. Therefore, this study can be extended on cluster or reason basis.
- In developing ISM model 14 factors have been considered. These factors are internal in nature as far as the quality of Technical Education is concerned. External factors viz. approval from AICTE, accreditation of various programs, Government policies can be considered for further studies and research.
- The research work has been limited to improve the quality in Technical Education. Research can be extended to non-engineering departments/colleges.