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Total Quality Management in Technical Educational System

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ABSTRACT

The Government of India is utilizing huge amount on the improvement in quality of technical education in the country. The various modeling techniques are available in the literature to evaluate the quality in technical education system are described . The best criteria for judging for best institution in the university system have also been suggested in this paper.

Keywords: *Quality Management; Technical Education; Institutional Improvement.*

1.0 Introduction

Education is an important aspect for the development of economy and to be self sustained. It predicts the growth and living standard. Technical education enhances further economic growth and provides livelihood to the needed. 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.

The main stakeholders of any 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 we have done research on various aspects of technical education by using different techniques. The basis of the research is provided by the literature review done.

- "Quality" means those characteristics of processes that satisfy the needs of customers (students) and thus ensure their satisfaction. The purpose of such higher quality is to ensure a greater satisfaction of students.
- "Quality" means lack of deficiencies – lack of such errors which result in exploitation, non satisfaction of faculty/staff and students.

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.

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

2.0 Technical Education Present-Past Scenario

Education depends on several mechanisms. A technical education system (TES) or process consists of three different stages, such as input,

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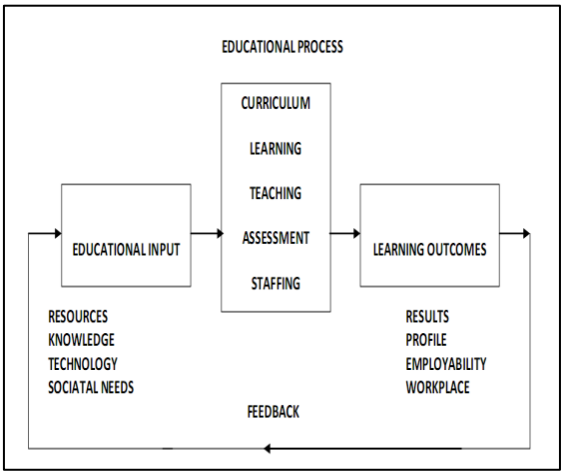
process and the output with a feedback mechanism which makes it a closed loop shown in fig-1.

Fig 1: Educational process [1]



Quality is a key factor for determining the success and survival. It is an important factor in manufacturing and service industries and has been extended to other fields across the world. Quality of a product is very important for an enterprise, it acts as a lifeline for the industries and hence they employ the best possible means to ensure quality of their product. The International Standard specifies requirements for a quality management system where an institute:

i. 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.
ii. 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.

3.0 Application of Total Quality Management in Technical Educational System

Quality is an attitude best defined not by the head of the institution/university but by those the system serves i.e. students. Various definitions of quality are:

- Deming defines quality as meeting and exceeding the customer‟s needs and expectations-and then continuing to improve.
- Juran 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”.

4.0 Parameters for total Quality Management in Technical Educational System

The important parameters in quality in technical education are as follow:

- 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 parameters have been considered further in analysis of quality in technical education system.

The major thrust areas to improve the quality of technical educational institutions are

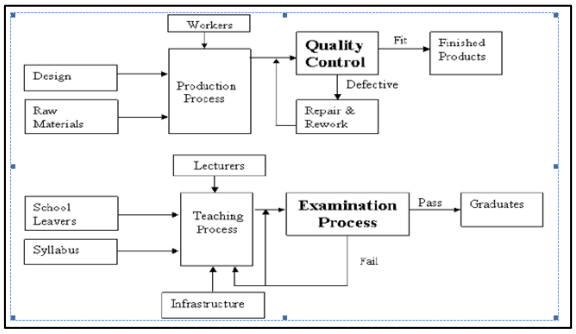
(i) Students Quality
(ii) Faculty Quality
(iii) Management Quality
(iv) Infrastructure in an Institution
(v) Accountability

The analogy between manufacturing system and educational system are shown in fig-2.

5.0 Literature Review

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.

Fig 2: Analogy between Manufacturing System and Educational System [1]



In 1975, Bakare (2) 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:

(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)

(4) and (Dynan, 1977) (3) looked at a more general aspects of success while Anderson et al., 1994 (5) 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 J. (6) 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 C. (2005) (7) 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 J. et al (2006) (8) 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 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) (9) 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 (10) 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. (11)

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.

Various scientists have done a lot of research in the field of technical education. The research is done for prediction of quality of technical education, quality assessment and quality management in 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 for quality management in technical education. Hence, there is need to apply these techniques and find whether these techniques can be used for quality management in technical education or not.

6.0 Factors Affecting Total Quality in Technical Educational Systems

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 exponentionally 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.
- These institutes are merely producing technical graduates which do not meet the expectations of the industries.
- 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 institutional have already come up and many are in the pipeline to get established.
- Further there is large 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.

The main Objectives of the present research study are

1. To develop quality management models for quality management and assessing in technical education which includes self assessment models, placement model, performance model, determination of attributes for a technical education system.
2. To develop strategies for improving the productive behavior and quality in technical education.
3. To develop competitive indices in terms of ranking of technical institutions in India.
4. To show the validity of application of the soft computing and artificial intelligence techniques in the field of quality management in technical education.

7.0 Research Methodoly

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 or methods have been employed by the researchers in order to achieve desired results.

Some of the techniques used 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 various institutions to control the quality of technical education all over the world.

In this work we have used various methods for improving and analyzing the quality of technical education. The techniques have been discussed below.

7.1. 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:

i. 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.
ii. The network is able to capture almost arbitrarily nonlinear relationships.
iii. With Bayesian methods, it is possible to estimate the uncertainty of extrapolation.

7.2. 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.

7.3. 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.

7.4. Statistical process control (SPC)

SPC stands for Statistical Process Control, 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.

7.5. Interpretive structural modeling (ISM)

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.

8.0 Results and Discussions

The research and methodology which gives a description of all the techniques used for research work. It also consists all the case studies done for quality management in technical education. A case study was done on comparison of different colleges under one university. 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 following parameters of acceptance have been considered. If the ranking is > or = 80% : it is center of excellence. If the ranking is 60% - 79%: the center/institute is of grade A.

If the ranking is 50% - 59%: the center/institute is of grade B. If the ranking is 40% - 49%: the center/institute is of grade C. If the ranking is < 40%: the center/institute is of grade D and it needs to be improved to enhance the quality of the engineering education. The following observations are.

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 the 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 and hence it is very helpful. The research depicts the need for good quality education and also shows its importance.

The techniques used in the research are the latest techniques and have not been applied extensively in this field. The results obtained were found to be very effective and satisfactory.

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. 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 Fuzzy Logic technique has been applied for prediction of the various factors of 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. 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. This approach suggests 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. Using MAT LAB technique gives us the precise information about where the problem exists and how much input is desired to improve the quality. Quality of teaching is a major focus for colleges and universities.

The management and monitoring of teaching process should be enhanced. 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 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. We can conclude that of the four Main Attributes, Faculty Quality is the most important, followed by Management Inputs, then Students Quality and in the end Infrastructure.

In terms of the Sub Attributes we can conclude 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. These enablers are important input for upgrading the standard of technical education and to compete with 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 therefore there is an imperative need to 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.

9.0 Conclusions and Recommendations

Most of the techniques used in this research work are the latest and indicate their effectiveness in achieving the desired goal in the quality in technical education. The following conclusions have been drawn.

- This research work shows the importance of above methodologies in the field of quality management in 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 the techniques namely, ANN, Fuzzy Logic and MATLAB, SPC, Fuzzy AHP and ISM have greatly helped in assessing and controlling the quality of technical education.
- The research is limited in this area and there is a scope of future work that can be done in this field of research. Techniques like nanotechnology, genetic algorithm, etc. can also be applied for quality management in technical education. So in future application of many other techniques can also be checked in this area of research.

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