Chapter II

LITERATURE REVIEW

2.1 Quality Concept

According to the Oxford English Dictionary, the notion of quality includes all the attributes of a thing, except those of relation and quantity. The British Standards Institution (BSI) defines quality in functional terms as the totality of features and characteristics of a product or service that bear upon its ability to satisfy the stated or implied needs [3]. Navaratnam makes it specific by defining quality in terms of functional utility of a product [4]. Oakland, after detailed analysis, concluded and defined quality as ‘the degree of fitness for purpose and function’ [5]. Sallis cited the examples of the overhead projector and ballpoint pens and exhorted in the name of quality, ‘they must do what they claim to do, and do what their customers expect of them’ [6]. Quality is thus a positive and dynamic idea achievable by design with meaningful investment; and not a negative idea of absence of defect [7]. Since quality is a dynamic and positive idea, it has endless possibilities of evolution and unfolding, making it an endless journey with a deliberate purpose and design and not necessarily a destination. Hence, exact definitions of quality are not particularly helpful when actual ‘consequences flow from different meanings attached to quality. The quality journey is characterized by a customer-focused approach to continuous improvement of processes, products and services through an interdependent system of planning, implementing, evaluating and decision making [8].

Quality has a variety of meanings. It is accepted fact that the term quality cannot be defined precisely. When the expression quality is used, one normally thinks in terms of an excellent product or service that fulfills or exceeds expectations. These expectations are based on intended use and the price. Quality is also a relative concept and cannot be measured in absolute terms.
Quality has three important dimensions

1) Quality for design
2) Quality for conformance
3) Quality for performance

The term quality is difficult and elusive to define, due to variety of meanings and connotations attached to it. Various authors and researchers dealt either with product/services or the services providing these product/services, while defining the quality. The important contributors along with their contributions in the area of quality are as follows [9].

Demming: PDCA cycle and 14 quality principles are basic important contributions
Juran: Known for concepts of ‘brake through’, internal customer, Pareto principal
Crosby: 14-points on quality other than Dr. Deming and known for the concept that ‘Quality is free’
Armand and Feigenbanm: Known for ‘Total Quality Control’ concept and 3 steps to quality -leadership, quality technology, and organizational commitment.
Jshikawa: Known for his view on statistical quality control, famous for Ishikawa diagrams
Garvin: Well known for 8 dimensions of quality- performances features, reliability conformance, durability, serviceability, aesthetics and perceived quality
Shingo: Known for Just in time in manufacturing and work on fail-safe devices
Tauguchi: Known for the concept ‘Quality through design’ Introduced cost function
Kano: Known for Kano model which consists of 3 factors - Basic, Performance and delighter factors.

All the above personalities have made significant contributions to Quality Management and Quality Improvements [10, 11].

Concept of Quality is not new. Historically during the 15th century Egyptians demonstrated a commitment to quality in the construction of their pyramids. During the early days of manufacturing, an operator’s work was inspected and a decision made
whether to accept or reject it. The focus was just to accept or reject the products based on specification. No effort was made on defect prevention. In 1920's statistical theory began to be applied effectively to quality control, and in 1924 Shewhart [12] made the first attempt of a modern control chart. His work was later developed by Deming and the early work of Shewhart, Deming, Dodge and Romig constitutes much of what today comprises the theory of statistical process control. However there was little use of these techniques in manufacturing companies until the late 1940's. In the early 1950's quality management practices developed rapidly in Japanese plants and became a major consideration in Japanese management philosophy, such that, by 1960, quality control and management had become a national preoccupation.

In 1969, Feigenbaum presented a paper in a conference and the term ‘Total Quality’ was used for the first time and referred to wider issues such as planning, organization, and management responsibilities. Ishikawa presented a paper explaining how ‘Total Quality Control’ in Japan was different and describing how all employees, from top management to the workers, must study and participate in the quality control. ‘Total Quality Management’ came into existence in 1980 through the western world. As we move in the 21st century, TQM has developed in many countries into holistic frameworks, aimed at helping organizations achieve performance excellence, particularly in customer delight and business results.
The Evolution of Quality concepts [13] has been shown in Table 2.1

### Table 2.1 Evolution of Quality Concepts

<table>
<thead>
<tr>
<th>Period</th>
<th>Input Methodologies</th>
<th>Outcome Philosophy</th>
<th>Problem diagnostics</th>
<th>Customer Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1940 AD</td>
<td>Final Inspection, Quality Control</td>
<td>Final Inspection + Inspection Quality Control</td>
<td>Problem Detection</td>
<td>Ignored about the relationships</td>
</tr>
<tr>
<td>Between 1941 to 1970 AD</td>
<td>SQC, QA, ISO 9000</td>
<td>System + Inspection</td>
<td>Problem prevention</td>
<td>No relationship with the customers</td>
</tr>
<tr>
<td>Between 1971 to 1989 AD</td>
<td>SQC, Kanban, QS 9000, NQA</td>
<td>Optimal + TQM</td>
<td>Problem reduction</td>
<td>Good rapport with customers</td>
</tr>
<tr>
<td>Between 1990 to 2004 AD</td>
<td>Six sigma, NQA Award Models, QFD</td>
<td>Perfection + TQM</td>
<td>Problem elimination</td>
<td>Business partners</td>
</tr>
<tr>
<td>Beyond 2005 AD</td>
<td>Six sigma, CIQM, Quality chain</td>
<td>Sustainable Quality + continuous innovation</td>
<td>Problem will exist?</td>
<td>Business partners + Consultants</td>
</tr>
</tbody>
</table>

Quality in education [14] has been variously defined as

- Value addition in education.
- Excellence in education.
- Fitness of educational outcome and experience for use.
- Conformance of educational output to planned goals, specifications and requirements.
- Defects avoidance in education process.
- Meeting and / or exceeding customers’ expectations.
Quality in education is determined by the kind of human being it produces and can not be restricted to the supplier specification and even apparent customer satisfaction in terms of employability. With reference to engineering education, quality may be defined as ‘Production of students having appropriate knowledge, skills and attitude, which can be readily employed by the employer and they can face any challenge through life long learning and become a good human being’ [15].

In India, the educational institutions in general are concerned with teaching knowledge and related skills. This is true for primary to higher education. Researchers have claimed that research is prestigious but teaching is not so. It is good to have a few institutions that are strong in research but we should have all the institutions strong in teaching. Good research should be encouraged but it should not be at the cost of teaching. Therefore National Assessment Accreditation Council (NAAC) gives a prime place to quality of teaching learning and related aspects during assessment of institutional performance [16].

2.2 Quality in Technical Education

N.B.Pasalkar [17] mentioned, the Radhakrishnan Commission recommended autonomy to institutions way back in 1959. The Kothari Commission, in its report of 1966-68, also prescribed autonomy. Again, in 1986, New Education Policy recommended autonomy to improve the quality of education. There is pre-condition enforced by All India Council for Technical Education (AICTE) / National Project Implementation Unit (NPIU) for inclusion of the institute in Technical Education Quality Improvement Program (TEQIP), to acquire the autonomous status for effective execution towards excellence. Autonomy avoids too many complex and lengthy procedures under the control of university, government etc. The University Grants Commission (UGC) and AICTE have issued guidelines to the institutes for acquiring autonomous status. Government of Maharashtra, on 19th July 2002, conferred autonomy to four engineering colleges, and extended the same to three more institutions in 2006. Autonomy avoids over centralization. Governance becomes responsive. The old affiliating system of colleges to the university is obsolete and needs to be discontinued. Affiliating system is non responsive to changing times, whereas autonomy can easily adapt to the need of the time.
The deterioration of quality in many of our higher education institutions have prompted the UGC to set up another autonomous body NAAC in 1994 to assess higher education of institutions in the country. NAAC has so far assessed and accredited over 2608 institutions including 122 universities and university level institutions as shown in Table 2.2

Table 2.2 NAAC Assessed Institutions

<table>
<thead>
<tr>
<th>Year</th>
<th>NAAC Assessed Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>8</td>
</tr>
<tr>
<td>1999</td>
<td>71</td>
</tr>
<tr>
<td>2000</td>
<td>44</td>
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<td>2001</td>
<td>50</td>
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<td>2002</td>
<td>83</td>
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<tr>
<td>2003</td>
<td>493</td>
</tr>
<tr>
<td>2004</td>
<td>1338</td>
</tr>
<tr>
<td>2005</td>
<td>1853</td>
</tr>
<tr>
<td>2006</td>
<td>2235</td>
</tr>
</tbody>
</table>

American accreditation board for engineering and technology has arrived at various norms for setting objectives, evaluating objectives for the engineering programs at graduate levels [18].

Good faculty and good systems are two key success factors enabling better performance of the system. Good faculty with poor system feels handicapped while good system with poor faculty quality does not achieve optimal performance [19].

However, these factors have received scant attention vis-à-vis studies on quality improvement in education.
2.2.1 Use of Total Quality Management- Quality Assurance System

Professionalism in governance is the need of the times. Quality assurance has assumed great meaning in governance of institutions. This essentially comes through TQM. Edward Deming, from USA is the pioneer of the technique. The Japanese economy has gained substantially from its use and has become an economic powerhouse. It is being used all over the world both in academic institutions and in industry. UK has made its use obligatory for institutions, which draw grants from government.

Pasalkar [17] has reported in his research about the views given by different eminent personalities on quality in technical education as follows

- Natarajan reviewed the framework for promoting quality in technical education in India, with particular reference to National Board of Accreditation (NBA). Bhatt has emphasized on having a quality assurance mechanism and elaborated on the NBA.

- Gupchup has further elaborated the role of NBA in quality assurance in technical education. Naik has strongly suggested bringing quality movement through application of TQM in Indian higher education in order to become an economic global power. He further said that a law should be made to have a quality assurance cell in every academic institution like in UK. Naik again mentioned that, according to the recent study, 90.58 % respondents from academics recommended the use of TQM. 88.41% say investment without TQM does not improve quality.

- Mohitkar gave detailed steps for implementation of quality assurance systems in technical education. Government of Maharashtra, based on the advice of Government of India, has set up a quality assurance cell at state level for monitoring the performance indices of the institutes and mentoring them accordingly and thus is propagating the philosophy.

- Mashelkar said that lack of visions, new visions of the new world, global perspectives, and global opportunities not viewed in proper perspectives are detrimental to society.
Instead of protecting inefficient institutions and investing in Government aided universities, the Government is now promoting private and foreign universities/institutes, in public interest. Economic returns from education in India are found to be fairly high. The returns are around 100%, as like very few industrial projects. The Government has borrowed a loan from World Bank to modernize institutions.

In view of the above, Government of India, has launched TEQIP for both government and un-aided institutions. The NPIU has specially been set up in New Delhi to look after the implementation and execution of this ambitious project. The loan has been disbursed in the form of grants to various institutions, selected under the project. Technical guidance and support is extended to them to incur this grant on various heads like equipment, faculty and staff training, infrastructure modernization, community development etc. This is essential to keep pace with the forces of globalization. India dreams to be a developed country by 2020. This cannot happen without strengthening quality in technical education.

Citing the example of Massachusetts Institute of Technology (MIT), Murthy in his talk on engineering education reforms, organized by Mysore Local Center Institution of Engineers India (IEI) on 3rd Jan. 2006 stated, ‘Nearly 150 companies come up each year through the efforts of its faculty and staff. There are nearly 4000 such companies in USA whose combined sales were worth 40 % of India’s GDP. This means the productivity of a MIT graduate is equivalent to the productivity level of nearly one lakh Indians. If India is to hold its own against global competition, the Information Technology (IT) workforce should leverage its ideas and skills and emerge from a low level to become strategic players in the business. He stated that India would have 47 Million IT professionals by 2020; this would be surplus for the Indian market. Indians could be the utilized in China and in the European markets, which are opening up. They, however, need competent engineers.

He further suggested that the focus of institutions should shift to R & D while joining hands with national and other International industries, to create more and better employment, and increase the employability of engineers. If the reforms in engineering education do not happen, he warned, that India would lose out on the global scenario.
Indian IT companies today have a 38% share in the global market. This may fall down if the quality of technical education is not improved.

2.2.2 Different Quality Management Systems

BS 5750 Standards

This was the originally developed quality system designed to cover all manufacturing activities. The initial approach was towards quality assurance and not really on quality management.

At this time it is pertinent to briefly discuss the quality development in the production industry. The initial step was quality control which was essentially a method for inspecting the finished goods and rejecting the ones not within the accepted tolerance limits. Quality assurance was more of a preventive initiative aimed at avoiding errors in production. Quality management considers all activities and management functions in an organization that affects quality [20, 21].

The BS 5750 was developed by the BSI. It consisted of a series of standards in three parts. Part 1 was for design/development, production, installation and servicing for organizations. Part 2 was for production and installation whereas Part 3 was for final inspection and test. These standards were almost identically adopted by the standards developed by the International Organization for Standardization (ISO).

ISO 9000 - Quality Management System Standards

ISO 9000:1994 Standards

The ISO developed these standards for the first time in 1987 as ISO 9000:1987. These were subsequently revised in 1994 as ISO 9000:1994. The standards were revised based on experience gained during their use in different organizations. The important modification included compulsory documentation of certain key procedures. The responsibility of the management was also more clearly specified. On the whole 1994 version provided more clarity with a special inclusion of use of statistical techniques [22].
The 1994 version was in three sets of standards namely ISO 9001, 9002 and 9003. The organizations, based on their activities, could adopt any one of them, establish and maintain the quality management system and eventually receive relevant certification by a certifying body after an audit. Out of these, similar to the BS 5750, ISO 9001 was applicable for organizations engaged in design, development, production, and installation and servicing. ISO 9002 was applicable for organization engaged in production, installing and servicing. Such organizations would be manufacturing their product by using a design from another organization. ISO 9003 was applicable for organizations engaged in final inspection and testing and was suitable for test houses, laboratories etc [23].

Revised ISO 9001:2000 standards:

The new 2000 version is now in use and after 13th Dec. 2003 all organizations with 1994 version have changed to the new version. The 2000 version of standards are more clear and simplified. ISO 9001:2000 now supersedes 9001:1994, 9002:1994 and 9003:1994. The new 9001 standard are quite comprehensive and an organization, based on its activities, would decide and declare as to which specific requirement is not applicable to it. A suitable entry about this is included in the quality manual of the organization.

Besides the three main standards referred above some other supporting standards have been developed by ISO. These are ISO 9000:2000 - Quality Management Systems - Fundamentals and Vocabulary. This has replaced the earlier ISO 8402. One other standard is ISO 9004:2000 - Quality Management Systems - Guidelines for Performance Improvements. This is to be used as guidelines by the companies that would like to improve beyond ISO 9001.

The 1994 versions were based on procedural approach. The emphasis was on documentation and following procedures and this resulted in enormous paper work. This system not only curbed creativity but also led to creation of compartments in the functioning of the organizations. The 2000 version is very reactionary and is based on process approach. It requires identification of different processes and sub-processes of an organization. These are then kept in mind while developing, implementing and operating the quality management system. The focus therefore has shifted from mere
documentation to the result of the process. The requirements of the new standards are based on the PDCA (Plan – Do – Check - Act) methodology [24].

2.2.3 Accreditation Initiatives in India

**National Assessment & Accreditation Council (NAAC)**

Realizing the importance of the vital role of education in the development of the country, the University Grants Commission has taken an initiative of establishing NAAC. A team from this organization visits the educational institutions and verifies the activities against set standards. This system helps in identifying the strengths and weaknesses of the institutions that are given a rating based on this verification.

**National Board of Accreditation (NBA)**

The institutes conducting technical education in the country must satisfy the requirements of All India Council of Technical Education (AICTE). The NBA, of AICTE, has now commenced a system of auditing the institutes for periodical evaluation against set standards. This effort aims at institutes continuously working at achieving quality in its activities.

**Accreditation: The Indian Situation**

During the past two decades there have been discussions in India regarding the formulation and functioning of an appropriate mechanism of accreditation. The ‘Program of Action’ related to ‘the National Policy on Education, 1986’, called for the development of "a mechanism for accreditation and assessment for maintaining and raising the quality of institutions of higher education". (Government of India, 1986). A National Assessment and Accreditation Council (NAAC) were established in 1994, with headquarters at Bangalore and it presently undertakes institutional evaluation, though there is also a provision for departmental evaluation. The principal objectives of this Council are to:

- Grade institutions of higher education and their programs,
- Stimulate the academic environment in these institutions,
• Help the institutions in realizing their academic objectives, and
• Promote changes, innovations and reforms necessary for the above purposes, and encourage innovations, self-evaluation and accountability in higher education.

In the case of professional education the establishment and recognition of institutions is presently regulated by different professional associations including the AICTE, the Medical Council of India (MCI), Indian Nursing Council (INC), Dental Council of India (DCI), Pharmacy Council of India (PCI), Council of Architecture, and Bar Council of India (BCI). However, these do not undertake accreditation. The AICTE became a statutory body in 1987 and was assigned the responsibility of setting up a NBA for periodic evaluation of programs of institutions under it. The NBA was established in October, 1994 and it undertakes program accreditation.

At NAAC, the process of assessment and accreditation is undertaken in three stages: first, the preparation of a self-study report by the institution undergoing assessment; second, the validation of the report through a peer-team visit; and third, a review of the peer team's evaluation, and the final decision regarding accreditation by NAAC.

NAAC follows a two-tier assessment system. At Level 1 the institution is first classified as ‘Accredited’ or ‘Not-Accredited’. At Level 2 the accredited institutions are graded into five categories, improving quality being indicated by an increasing number of stars as superscript to the letter A (indicating accredited). Thus A* indicates the threshold level of quality and A***** the best quality.

For the purpose of grading seven parameters are considered. These are: curricula aspects; teaching-learning and evaluation; research, consultancy and extension, infrastructure and learning resources; student support and progression; organization and management; and healthy practices. For the three types of institutions, namely colleges, universities and autonomous colleges, different weightage have been assigned to each of these parameters. From parameter-wise judgment of the peer team, and after taking into consideration the assigned weightages, a composite Institutional Score (IS) is calculated. The IS is then used for grading the institution on a five-point scale (A***** the highest and A* the lowest) [26]. Till the end of December 2000, NAAC had assessed 22 universities and 123 colleges.

The procedure followed by NBA is essentially similar to that at NAAC and involves submission of information and data on a proforma provided by NBA, visit of peer-team and
consideration of its report, first by a sectoral committee and then by NBA. The decision is finally reported to the AICTE. The assessment is based on the following criteria: mission, goals and organization; physical resources, and their utilization; human resources - faculty and staff; human resources - students; teaching-learning processes; supplementary processes; industry - institution interaction; and research and development. The assessment is on a four-point scale - A (Excellent/very good), B (Good), C (Satisfactory) and NA (Not Accredited). In case of both NAAC and NBA accreditation is valid for five years [25, 26].

Accreditation in India is in its infancy. The implementation of this laudable concept is being examined. Hopefully, mid-term corrections will be made. The success of accreditation is important from the viewpoint of maintenance of standards.

**Total Quality Management (TQM)**

The acceptance and adoption of the philosophy of TQM in the manufacturing sector was comparatively easy and many industries have opted for this. In the service sector though, the acceptance of TQM is not so smooth. In the service sector the work being done is the product and the employees of the organization substantially influence the quality of product. The adoption of TQM philosophy has been somewhat slow in the service sector. The intangibility of the services makes it difficult to set standards, monitor the processes and thereafter analyze and measure the performance and compare with the set standards.

In the education sector this adoption becomes still more difficult as the student himself becomes part of the process and therefore has a great impact on the quality of product. The teachers, while curious about the quality jargon, feel threatened by the induction of this new management concept and are naturally adverse to the change. However, in the competitive environment of today few schools have voluntarily started working towards achieving TQM [27].

**Six Sigma**

This is a system aimed at near elimination of defects. It was launched by Motorola in 1987 and it is claimed that the company achieved a cost saving of 13 billion $ in the period 1987-1997 [28].
The objective of this technique is to reduce the defects to 3.4 parts per million and it is a further advancement from TQM. While this philosophy is good for the manufacturing industries where the operations can be controlled in great detail, the application of six sigma in service industries is still limited. Probably the education institutions may opt for this technique and slowly start from aiming to achieve 3.5 sigma (22,700 defects per million) and thereafter graduate to six sigma.

2.2.4 Review and Earlier Work Done

The three important aspects of quality, namely quality of design, quality of conformance and quality of performance were analyzed by Grant, Mergen and Widrick [29].

Welsh and Dey in their work emphasized the importance of measurement of quality and referred to the quality assurance program at the University of Louisville. They also identified different entities whose satisfaction level is considered important from the quality point of view. This issue was also studied by Aldridge and Rowley where student's satisfaction level was considered [31].

Kanji and Tambi took up the issue of TQM in UK and the customers in higher education were identified. Some models for TQM were considered for their suitability to the local environment [32].

Andrews raised the question of faculty evaluation and its relevance. He also identified different barriers in implementing this in a classroom environment [33].

The cultural issues and barriers in the implementation of TQM in higher education and the importance of culture in international education were addressed by Newby [34].

In India Mohanty has brought out different aspects of quality improvement issues in the higher education. The ranges of activities addressed include intake, curriculum, feedback etc. Similarly the question of teachers' attitude towards their evaluation by the students is described by Mathew [35]. The application of quality circles is taken up by Sharma and Kamat. Natarajan has carried out Strength-Weakness-Opportunity-Threat (SWOT) analysis of the engineering education in the country [36, 37].
2.3 Role of Quality in Modern Education

Although the modern day concept of quality originated with Deming about 50 years back in 1950, the ancient wisdom of India contained in the Shree Bhagwat Gita 4000 years back defines ‘true quality’. A teacher’s work is different from a work done by a machine. A machine works mechanically and efficiently turning finally into scrap. A teacher, on the other hand, by linking his work (Karma) with an inner vision (Spirit) transforms the performance of duty into Yoga. This ultimately leads to Karma Yoga. The performance of such karma yoga converts into dexterity, efficiency, and excellence thereafter every action of duty enriches and strengthens the inner spirit preventing him from turning into scrap. The glorification of a teacher into an Acharya takes place when the teacher converts ‘Work into Service’ [38].

The quality education in an information age is experiencing transition from service sector to industry. Similarly education is making shift from individual to group education, to mass education, to global education, to networked education and to distance education. The adoption of industrial approach in education thus has central concern to make education user friendly, cost effective, employment oriented, adopting pragmatic approach inculcating primary, secondary and specialized scales among the learners to boost productivity and quality. The process of quality development in education works on the principles namely, value addition through instructions, guidance and making a student socially useful for the society. The application of the principles of quality in education facilitates an institution to produce a student an efficient self reliant, productive human resource [39].

Development of quality in education needs a dynamic methodology of education promoting fast access, easy connectivity, and enhanced interactivity, and enriched content, relevant curriculum with respect to employment market. Practically, quality can no longer tolerate stagnant teaching – learning methodologies both in the non-conventional and the conventional systems of education because stagnant system of education cannot tolerate a dynamic teacher. Therefore a conventional system cannot permit a teacher to make teaching relevant to the needs of the society e.g. book oriented, subject oriented and examination oriented. Such systems of education are rather unable to
provide the requisite opportunities to the teacher who wants to promote the objective of integral personality [39].

Quality management is not a destination but rather a journey to improvement. It is always preferred to deal with concept of ‘stakeholders’, which could very widely depend on Institution’s mission, goals, strategies and tactics. The stakeholders can be suppliers, such as high schools, and receivers such as employers, parents and students. Here a concept of concurrent engineering design of any product is taken into consideration and used as a base for developing concept behind stakeholders in education process. In concurrent engineering representatives of all the departments in the company are coming together for designing of new product likewise suppliers (e.g. teachers, publishers, parents) and employing industries as a user can come together for designing a education process by which society will get benefited at large.

Concept of quality in industry can be compared with the concept of quality in education through the processes involved in both the activities as shown in the Figure 2.1 [14].

**Industry**

![Industry Diagram](image)

**Engineering Education**

![Engineering Education Diagram](image)

Figure 2.1 Quality in Industry and Quality in Education with the Processes Involved
The role of feedback is important but has received little attention. We know that in 21st century industries are working towards data driven technology for improving the quality of product, quality of services. In education also application of data driven technology to find and work on weak areas of teaching process and improve the quality of education, is required. In this regards, a lot can be borrowed from quality management in industry [40].

2.4 Engineering Education in India [17]

Engineering education in India contributes a major share to the overall education system and plays a vital role in the social and economic development of our nation. In India, technical education is imparted at various levels such as degree, diploma, PG and research in specialized fields catering to the various aspects in technological development and economic progress. The intake capacity of institutions offering technical education has increased manifold over the years. To maintain high quality and for proper planning and coordinated development of the technical education system in the country, Government of India has established a statutory body called AICTE in1987. The AICTE aims at regulation and maintenance of norms and standards in the technical education system. Worldwide scenario of technical education varies naturally according to economic strength, educational heritage, civilization and sometimes local demands of the particular country.

2.4.1 Brief Scenario of Technical Education – Worldwide

Engineering education, unlike other types of professional education, has not had a long history. Though the ancients and medieval had built large brick and stone houses, castles, cities and huge temples, badly constructed long highways, aqueducts and dug canals, which show considerable knowledge of what are now known as civil and hydraulic engineering and of properties of building materials, this knowledge must have been derived empirically. The beginnings of mechanical engineering are to be found in the
manufacture and use, of tools, means of transport, simple machinery like lathes, and weapons of offence and defense. Rudiments of chemical engineering are to be seen in the old metallurgical practices. But there were no organized schools for teaching apprentices the use of machinery or knowledge of processes; knowledge passed from generation to generation of craftsmen and artificers, by word of mouth, and was thus confined to castes and guilds.

2.4.2 The Industrial Revolution

With the advent of the industrial age, which was ushered in by the discovery of the steam engine by James Watt in about 1780, and the ability to generate and handle large amounts of power rendered possible by the invention of the steam engine, men passed from dependence on human labor and hand tools to large and complicated machinery. Production of commodities passed from cottage workshops to factories. Transportation by bullock-carts, horse-driven carriages, and wind or man driven boats, gave way to railroads and steamships. All this necessitated the construction of large machines, engines, ships and carriages, and gave rise to problems of industrial finance and labor.

2.4.3 Growth of Engineering Sciences

The 19th century has witnessed the birth of many branches of engineering and technology in addition to the classical ones of civil and mechanical.

The range of development in engineering and technology gave rise to list of separate engineering fields, which are recognized and in which four/ five years of under-graduate courses leading to a degree are offered in universities and colleges. Within each one of the fields, there are further sub- divisions and specializations, each being the subject of special postgraduate study and research.

Technology and engineering are products of fundamental discoveries in basic sciences. As is well known, these began to accumulate in the late 19th and early 20th century and in greater variety than in all the previous centuries of civilized life. Thus new branches of engineering began to grow.
2.4.4 Technical Education Scenario - Nationwide

Our great saints and seers have been showing the entire world the path of enlightenment leading to the ultimate truth since the dawn of civilization. Even during the Vedic period (100-800 BC) India had some of the prominent institutions of higher education, which attracted scholars from different parts of the world to come to India in pursuit of knowledge. Universities of Takshashila and Nalanda survived till the end of the fifth and twelfth century AD respectively. The other Vedic centers of education were located at Vallabhi, Vikramshila, Kashi, Nadia, Ujjain and Kanchi.

The high quality of the manufactured articles available during the medieval period is proof of the excellent system of vocational training. People took great interest in vocational education on account of which trained workmen of every trade were available in abundance during that period. The importance of technical education in the new industrial age in India was realized in the second half of the 19th century, resulting in the establishment of modern universities and leading institutions in India.

2.4.5 Technical Education for National Development

It is generally agreed that at the core of all national development efforts, is the intensive application of science and technology to increase agricultural and industrial productivity. But for this to happen, an important investment that any country has to make, is in its human resource- in the education and training of its people. Educated people constitute an essential prerequisite to national development, and education along with technology, is responsible for the acceleration of economic growth.

Technology is increasingly involved in human activities. It is becoming a permanent component of the socio-economic fabric of modern society. Also it has become a powerful means of projecting the national influence into the international arena. An engineer or technocrat trained through the technological education system must be an efficient and well prepared agent of technology. He must also be an honest civic leader able to advance technological paths for solving societal problems. The results of the
education process become a national benefit to the extent that they are energetically applied to areas of national needs. A surplus of graduates in undesirable fields can prove wasteful of youth and enthusiasm, while trained manpower in desirable areas can bring laurels. The professional education system which moulds engineers and technocrats, must promote the ability and the habit to think independently and for a team, to apply the acquired information, skills and knowledge for problem solving within a stipulated time. The institutions, the Universities, the trainers, the curricula, the learning environment, and the assessment schemes, all should work responsibly in unison, so that the final product of the system becomes most acceptable, employable, by industry and contributes in effect to national development [41].

2.4.6 Privatization to Promote Competition

Government of Maharashtra, from 1981, has adopted the policy of privatization, in Technical education and there has been a quantitative expansion in engineering education. Around 45,000 students are facilitated through admission in technical institutes. Maharashtra State could make a mark in software industry, because of private engineering colleges. However, the quality is yet to be improved. To make the scheme of private colleges more successful, private universities are being proposed. The bill for this purpose has been introduced by the state assembly in 2006. American universities have become superior and have gone ahead of European universities because they adopted privatization. At present only 6% of youth in the age group of 17 - 23 go to higher education. Government of India aims to increase this to 10 %. The countries like USA have corresponding figure of 55%. In knowledge society of today, educating more and more in institutes of higher education is needed so as to make the economy competitive [42].

Pasalkar [17] in his work on quality management says “weak or non existent governance is at the heart of poor education quality and exploitation of students in India”. He stressed on well-defined faculty norms and incentives for research, publication and patents. There are very few competent faculties at par with those in developed countries. Professional
management from elementary school education to higher education is missing. Recruitment of high potential faculty and effective strategies for retention must be developed and adopted.

P. Chidambaram and Bill Gates both identified “Mental block in India” vis-à-vis the concept of private universities. Indian Institute of Technology’s (IITs) are nurseries of world-class engineering graduates but not necessary cauldrons of cutting edge research. The government has now come around to the view that teaching and research must be a seamless continuum in all the institutions. This is the vital factor responsible for quality in technical education [43, 44].

2.4.7 Engineering Education

Engineering is the profession in which knowledge of mathematical and natural sciences, gained by study, experience and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind. Engineers turn ideas into reality; they create useful products and systems through playing with imagination and possibilities, leading to new and meaningful connections and outcomes while interacting with ideas, people and environment.

The Engineering profession has evolved in a dramatic way over the past few years. Engineers are no longer confined to fulfilling specific task of a support nature only. Their involvement is much more encompassing and they tend to assume much broader roles with higher organizational objectives. They manage technological systems, resources and projects and contribute substantially by adding value to organizational performance. The modern competitive nature of organizations has placed more emphasis on integrated roles and the ability to manage projects on cross functional basis. This is considered to be necessary for linking organizational internal strengths to the competitive market externally. As far as engineers are concerned, their role has been broadened to cover aspects of organizational competitiveness. Macro-engineering awareness is perceived to be the element of their education/ training which will enable them to understand how large systems operate including people processes, machine processes, market behaviors, suppliers etc. Educational establishment needs to redesign the curricula and are required
to be more innovative in providing skills according to the industry demand. The concept of stakeholders under TQM umbrella is affecting most educational establishments supplying skills to industry [45].

Engineering education is currently at crossroads. It can continue to function through face to face interaction at university type institutions using modern information technology tools and web based education. It can concentrate on developing only technological excellence among its graduates or equipping them with professional and business requirements of quality and competitiveness in the design, fabrication and utilization of engineering products, services and systems.

Education related to technology offer ‘Degrees’ certificates once the students accomplished their studies successfully for the undergraduate course. At pedagogical level, engineering courses are basically theoretical and practical oriented and are supposed to generate knowledge as well as employment opportunities. Engineering programs have flourished with new areas and knowledge like Computer Science, Software engineering etc. has generated a lot of employment opportunities.

Engineering graduates today require not only adequate technological ability and problem solving skills, but must also be endowed with soft skills like co-operative working, communication and presentation skills, business ethics, inter-personal relationship, and possesses a deep commitment to safety, reliability, quality and sustainability of all engineering activities. The twentieth century has witnessed a phenomenal rate of growth and advance in technologies. The half life of many technologies are already much lower than the conventional four year first degree program. The rapidity of technological obsolescence is compelling the education system to ensure that students during their stay in the institution develop an attitude for life long learning and acquire self-learning skills. Continuous learning is an essential part in any quality engineering education system [18]. After India’s independence engineering education was given a prime importance by Indian Government to realize a dream of a modern India. Consequently, the number of students in engineering educational fields grew gradually. But the situation did not remain the same. During 1990, due to economic reforms and changing education policies,
demand for Engineering colleges and enrollment of students in them increased due to new areas of engineering which promised employment opportunities.

After independence, there has been a phenomenal growth in higher education in terms of quantity. From thirty universities, 591 colleges, 21,244 teachers and 2,28,300 students enrolled in 1947 - 48, today we have more than 294 universities, 13,150 affiliated colleges, 4,27,000 teachers, and a student strength of 88,21,000. This unprecedented increase in numbers in last 50 years, coupled with unmatched increase in infrastructure which has led to dilution in standards, quality and excellence [46].

At the time of independence, the country hardly had an industrial base and trained manpower for the task of nation building. Soon after independence, many large projects were undertaken to meet the needs for irrigation, flood control, power, and to establish infrastructure in steel, machine tools, fertilizer, transportation, drugs and pharmaceuticals, petrochemicals etc. The major struggle in implementing these projects was acute shortage of trained technical manpower. To meet the requirements, technical education expanded capacity of the engineering graduate output of professional colleges, such as engineering colleges and technical departments of universities.

**Degree Level Education in Engineering**

The total number of institutions imparting Degree level education was only 44 in the year 1947. Prior to 1950 i.e. first five-year plan the number increased to 53. In 1960 due to fast development of technology in all the fields, the number increased to 102. Subsequent increase took place as shown in Table 2.3

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>145</td>
</tr>
<tr>
<td>1980</td>
<td>158</td>
</tr>
<tr>
<td>1990</td>
<td>302</td>
</tr>
<tr>
<td>2000</td>
<td>880</td>
</tr>
<tr>
<td>2002</td>
<td>1195</td>
</tr>
</tbody>
</table>

Table 2.3 Growth of Engineering Institutions
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>1280</td>
</tr>
<tr>
<td>2006</td>
<td>1350</td>
</tr>
</tbody>
</table>

During the period of 2000 to 2002 this number increased by 350 more institutions and the total number of institutions went to 1195 by 2002. With this rate of increase in number of Degree Institutions one can easily predict the number of institutions increased by the period 2010 must be around 1600. Corresponding to the growth of number of institutions, the intake capacity for under-graduate programs in engineering education also increased significantly.

For the period 1990-2000 in these 10 years the total sanctioned capacity rose from 66,600 to 2,28,511. This period may be considered to be the most important period in the context of growth of under-graduate engineering education in the country. During this time number of institutions went up by 580 and stood at 880 by the year 2000, implying almost 200 % increase over the period. The sanctioned capacity has further increased sharply during 2000-02 and reached 3,48,400 in the year 2002 i.e. about 52% in just 2 years with 300 new institutions [18].

Region-wise Distribution of Sanctioned Intake in 2006 Figure 2.2 and Share of Engineering Colleges based on intake Figure 2.3 has shown below to get overall information on growth in percentage.
Figure 2.2 Region-wise Distribution of Sanctioned Intake [47]

<table>
<thead>
<tr>
<th>Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private</td>
<td>76%</td>
</tr>
<tr>
<td>Government</td>
<td>21%</td>
</tr>
<tr>
<td>IITs NITs</td>
<td>3%</td>
</tr>
</tbody>
</table>

Figure 2.3 Share of Engineering Colleges Based on Intake (2006) [47]
2.4.8 Growth of Engineering Education - Reasons

Some of the reasons behind the phenomenal growth of engineering education are listed below.

- Increase in production of automobile sector, which is considered as backbone of economy growth of the country
- Industrial growth in all sectors of manufacturing
- Computerized operated machines got introduced and these machines and operators of these machines replaced skilled labor
- Use of computers in all manufacturing sectors
- Industries started demanding higher educated manpower for the operation of the production shops
- Demand and supply gap for the employment in the market.

The growth of engineering institutions in an uncontrolled manner has serious implications for the viability, quality and credibility of the Indian technical education system. This is already getting reflected in the fact that a large number of seats reportedly remain unfilled in private engineering colleges in recent years. As a result, these institutions tend to shuffle the admission capacity between disciplines, leading to unhealthy practices in the tenure of faculty and necessary infrastructure resulting in compromises on quality of the institutions. With the rapid growth in the number of engineering institutions, non-availability of adequate number of competent faculty has emerged as a serious problem. Faculty shortages have been seriously undermining the quality of technical education [18].

2.4.9 Growth of Engineering Education – Post Independent Era

The Government of India has recognized that the future economic and industrial growth of the country entirely depends on the quality of technical education imparted in our institutions and the type of practical training provided to enable the future generation of engineers to become competent innovators, designers and product manufacturers.
Consolidation and quality improvement in the field of technical education was given importance during the period 1967 – 1980. The Indian Society for Technical Education (ISTE) and four Technical Teachers’ Training Institutes (TTTIs) contributed sizably towards this goal.

The ISTE was registered in 1967 as a national professional society of teachers and administrators of engineering colleges and polytechnics with the main objective of advancing the cause of technological education in the country. As a strategic partner of AICTE, ISTE has been organizing summer and winter schools for the teachers of degree engineering colleges and polytechnics every year since 1965. About 3100 programs have been arranged in which over 75,000 teachers have participated till date.

On the recommendation of AICTE, the government established four Regional Technical Teachers’ Training Institutes at Bhopal, Calcutta, Chandigarh and Madras in 1967, to meet the requirements of developing technical education in their respective regions.

The Apprentices Act of 1961 which sought to regulate and control the training of apprentices in trades was amended in 1973 with a view to bring the training of engineering graduates and diploma holders within its purview.

The Central Government formulated a program of quality improvement for improving the standard and quality of technical education with particular reference to developing the faculty of engineering colleges and polytechnics. This scheme was approved by AICTE in 1969.

A measure of far-reaching importance was initiated during 1976 – 1977 when the scheme of direct central assistance to selected engineering colleges was started in order to bring about a qualitative improvement in the standards of technical education.

In 1979, the Government of India published a new draft of national policy on education-1979, which advocated the need for creation of machinery for dissemination of information relating to manpower needs in the field of technical education.

The National Policy of Education (NPE), 1986, was a major development in the field of education in India. For the first time in the country, a national debate was initiated by
publishing a document titled ‘Challenge of Education’ which resulted in a blueprint for national policy on technical education.

After 1990, the spirit of globalization was responsible for industrial growth and competition. Not only quantitative but qualitative demand of technical manpower received a boost. In order to meet these requirements, privatization of professional education is being promoted to supply skilled technical manpower in adequate number.

Around 2000, global demand and expansion in the Information technology led to exponential growth of IT and IT enabled services. This in turn resulted in establishment of IT specific courses throughout the State.

After 2005, stabilization of Indian Economy and continuous growth of GDP (more than 8% per annum) resulted in huge expansion of Indian Industrial sector. This in turn, helped to gear up expansion of Technical Education in the State of Maharashtra.

### 2.5 Engineering Education in Maharashtra

The formation of the State of Maharashtra in 1960 opened a new chapter in technical education and the activities of the Directorate increased manifold. With industrial development, the need for technical manpower grew to a large extent. To cater to this need, new industrial training institutes, polytechnics and engineering colleges were started. These institutes produced skilled workers, technically qualified supervisors, and shop floor and design engineers. By 1978, the number of degree level institutes rose to 16, the diploma level institutes to 50. Also, post-graduate facilities were developed in nine institutions. Similarly, the ITIs and technical high schools also increased in large numbers. By 1987, almost every district, excepting the four districts of Ahmednagar, Wardha, Gadchiroli and Raigad had a government polytechnic.

However, the demand for degree courses was on the rise. Many deserving students were unable to get admission to these courses due to the limited seats available in government and government-aided institutes. Therefore, by a pragmatic view to give opportunities to the aspiring students, the government decided to grant permission to private, social and educational managements to startup unaided engineering colleges.
Due to the very large growth, and in order to facilitate monitoring and development of technical institutes and courses, the Directorate of Technical Education was bifurcated in 1984 and the Directorate of Vocational Education and Training was formed. This new Directorate was given the charge of industrial training institutes, technical high schools and certificate course institutes in the state.

The Directorate of Technical Education was given the responsibility of degree and diploma level institutions in Engineering and Technology etc. The Directorate was also entrusted with the monitoring and control of management institutions imparting degree and diploma level training in various branches of management.

### Quantitative Growth of TE in the State

The present status of engineering institutes with the sanctioned intake is given in the Table 2.4 below.

<table>
<thead>
<tr>
<th>Type of Course</th>
<th>Details of growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year of reference</td>
</tr>
<tr>
<td>Degree in Engineering and Technology</td>
<td>1980</td>
</tr>
<tr>
<td></td>
<td>1990</td>
</tr>
<tr>
<td></td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>2007</td>
</tr>
</tbody>
</table>

The advancements in technology necessitated starting new courses in the new and emerging areas to cater to the needs of industry and society. Therefore, the permission to the non-aided institutes was granted for the courses in new and emerging technologies. Thus, non-conventional degree courses titled Industrial Electronics, Computer and Information Technology, Petroleum and Polymer, Biomedical Engineering, Construction Technology, etc. were granted permission. Similarly, courses such as Leather Technology, Packaging Technology, Foundry Technology, Tool Design, Plastics and Polymer Engineering, etc. are also started through Government institutions under the World Bank assisted project.
To enhance the industry-institute interaction and to expose the students to industrial working, sandwich pattern courses were instituted at degree level.

### 2.5.1 Information of Technical Education Institutes in the State of Maharashtra

The consolidated statistical information pertaining to the technical education in the state of Maharashtra is given in Table 2.5.

**Table 2.5 Number of Institutes Along with Sanctioned Intake under DTE**

<table>
<thead>
<tr>
<th>Engineering Colleges</th>
<th>No. of institutes</th>
<th>Sanctioned Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Government</td>
<td>6</td>
<td>2140</td>
</tr>
<tr>
<td>b) Government Aided</td>
<td>12</td>
<td>2596</td>
</tr>
<tr>
<td>c) Unaided</td>
<td>152</td>
<td>50955</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>170</strong></td>
<td><strong>55691</strong></td>
</tr>
</tbody>
</table>

The statistical information pertaining to the Course-wise intake capacities for the most popular branches in Engineering 2007–2008 in the state of Maharashtra is given in Table 2.6 below. This information belongs to 16 branches of engineering out of 46.
Table 2.6 Course-Wise Intake Capacities in Engineering 2007–2008

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of Course</th>
<th>Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Computer Engineering and Technology</td>
<td>10980</td>
</tr>
<tr>
<td>2)</td>
<td>Electronics and Tele-Communication Engineering</td>
<td>9555</td>
</tr>
<tr>
<td>3)</td>
<td>Mechanical Engineering</td>
<td>8955</td>
</tr>
<tr>
<td>4)</td>
<td>Information Technology</td>
<td>7215</td>
</tr>
<tr>
<td>5)</td>
<td>Electronics Engineering</td>
<td>4320</td>
</tr>
<tr>
<td>6)</td>
<td>Civil Engineering</td>
<td>3230</td>
</tr>
<tr>
<td>7)</td>
<td>Electrical Engineering</td>
<td>2505</td>
</tr>
<tr>
<td>8)</td>
<td>Chemical Engineering</td>
<td>1510</td>
</tr>
<tr>
<td>9)</td>
<td>Instrumentation Engineering</td>
<td>1460</td>
</tr>
<tr>
<td>10)</td>
<td>Production Engineering</td>
<td>800</td>
</tr>
<tr>
<td>11)</td>
<td>Electronics and Communication Engineering</td>
<td>780</td>
</tr>
<tr>
<td>12)</td>
<td>Bio-Medical Engineering</td>
<td>300</td>
</tr>
<tr>
<td>13)</td>
<td>Textile Engineering/Technology</td>
<td>285</td>
</tr>
<tr>
<td>14)</td>
<td>Bio-Technology</td>
<td>270</td>
</tr>
<tr>
<td>15)</td>
<td>Automobile Engineering</td>
<td>220</td>
</tr>
<tr>
<td>16)</td>
<td>Industrial Engineering</td>
<td>120</td>
</tr>
</tbody>
</table>

The statistical information pertaining to the development of engineering program in the state of Maharashtra is given in Table 2.7. Development details are given in Table 2.8 and subsequent rise in intake capacity is shown in Table 2.9 below.

Table 2.7 Engineering Program Development

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>10</td>
<td>11</td>
<td>68</td>
<td>170</td>
</tr>
</tbody>
</table>
Table 2.8 Engineering Program Development Details

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Govt. Aided</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Unaided</td>
<td>0</td>
<td>33</td>
<td>77</td>
<td>153</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10</td>
<td>44</td>
<td>90</td>
<td>170</td>
</tr>
</tbody>
</table>

Table 2.9 Intake Capacity of Engineering Colleges in Numbers

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering Colleges</td>
<td>1865</td>
<td>14682</td>
<td>22740</td>
<td>55691</td>
</tr>
</tbody>
</table>
Growth Analysis of Various Streams under Technical Education Seats Availability:
Figure 2.4 shows number of seats available for engineering stream in Pune University, for three consecutive years from 2005 to 2007. It is clearly visible that significant increase in number of seats has taken place in Pune University.

![Bar graph showing seats available in Pune University for engineering stream from 2005 to 2007.]

**Figure 2.4 Number of Seats Available in Pune University for Engineering Stream, for Three Consecutive Years from 2005 To 2007**

2.5.2 Engineering Aspirants

Figure 2.5 shows number of aspirants for engineering stream in Pune University for three consecutive years from 2005 to 2007. Noticeable and significant increase in number of aspirants for engineering education for Pune University is clearly visible. This indicates:

- Increased awareness for professional Education
- Increased and attractive job opportunities
- Better Quality of Education
In addition to this, Centralized Admission Strategy of our State, which facilitates to seek admission in any Institute of the State just by filling a single application form, is also responsible for more number of aspirants in Pune University.

![Bar chart showing the number of aspirants in Pune University for engineering stream for three consecutive years from 2005 to 2007.](image)

**Figure 2.5 Number of Aspirants in Pune University for Engineering Stream for Three Consecutive Years from 2005 To 2007**

### 2.5.3 Factors Responsible for Growth

From the analysis of University wise seats availability, it is evident that the growth in establishment of technical institutes in the state of Maharashtra is primarily concentrated in the metro cities like Pune, Mumbai and Nagpur. This growth can be attributed to

1. **Educational Culture:** Standing of Pune and Mumbai Universities since more than 100 years has been a major contributing factor for the development of many World renowned educational Institutes like Veermata Jeejabai Technical Institute (VJTI),
Mumbai, College of Engineering, Pune, Institute of Science, Mumbai, University of Chemical Technology, and Mumbai. These Universities created conducive environment for setting up of large number of Educational Institutes in these regions. This, along with forward looking policy of the State Government resulted in influx of large number of students to these regions from all over India and abroad too. The peaceful, stable and open culture of the State is also a major contributing factor in the growth of education sector.

2. **Industrial Background, Establishment of IT Parks and Special Economic Zones (SEZs):** In terms of per capita income, Maharashtra is among the richest Indian states. Establishment of Maharashtra Industrial Development Corporation (MIDC) in 1962 led to the Industrial revolution in the State. The key historical policy decisions taken by the state certainly changed the social economic scenario of the state as industrial activities spread in the interior. Industrial growth stabilized the population base near the industrial areas developed in western parts of Maharashtra especially the automobile hub in Pune houses major companies like Tata Motors, Bajaj Auto, and General Motors etc.

IT parks in Navi Mumbai, Hinjewadi, Pune, SEEPZ, Andheri in Mumbai have established scores of IT, IT-enabled services and business process outsourcing units. Industrial development in the Mumbai, Pune, Nasik and Aurangabad region resulted in huge requirement of skilled technical manpower. This has fueled growth of Educational Institutes in the western Maharashtra creating manpower as per the needs of the industry.

Government of Maharashtra has undertaken ambitious plan for industrial development. Seventy-one special economic zones with an investment of Rs. 32,000 Cr. have been approved. Many more are in pipeline. The leaders in industry and their associations have been urging the government to step up quality and quantity of engineers and managers. Professionals from other States and countries with increased mobility are coming in our State. From world experience it is realized that sustaining and increasing rate of growth in competitive environment is not a contribution of capital investment alone. It requires highly qualified and trained human resources. Professionals are required to be competent by nothing less than global standards. This requirement is fulfilled to a large extent by the institutes established in Mumbai and Pune region.
3. **Awareness for Higher Education among Society:** Towards the end of 19\textsuperscript{th} century, many visionaries and educational leaders contributed to the ‘Education Revolution’ in the State. This helped to spread the awareness of importance of education across the entire social fabric of the state. These visionaries promoted Institutes of high learning in Pune and Mumbai. The subsequent growth of education in these regions, helped to boost more awareness among the people.

4. **Job Opportunities:** Maharashtra has been the hub for Industry jobs from the beginning of 20\textsuperscript{th} century. The progressive policies of the Government have encouraged huge industrial investments in the recent past. This has resulted in attractive job opportunities in multiple sectors like Engineering, ITs and Finance etc. The reputations of Pune and Mumbai Universities have made a mark in the industry as the proximity of the industrial environment helped the students in these regions to develop multi dimensional skills required for industry.

2.5.4 Engineering Education

It is evident that candidates as well as parents are opting for the quality education in spite of higher level of fees in these institutes as the figures under the column count indicates. It may be also noted that majority of these institutes have been accredited by the NBA. This shows that the students and parents, both the stakeholders, are aware of the accreditation and hence quality of education. Most of these institutes are having standing of more than 20 years. Majority of these institutes are located in Mumbai and Pune region. This adds to our belief that the geographical location definitely matters in the choice of institute. Those who do not have the accreditation as well as long standing have earned the reputation through quality consciousness, excellence of infrastructure and faculty.
2.6 Review of the Work Done in Recent Times

Natarajan [49] in his paper on quality and accreditation in technical and management education has talked in general on quality concept. He has also touched upon the areas of academic quality quantification. Accreditation of the institutions and NBA framework. It is said that there is an implicit and cyclic relationship among institutions, faculty, students and their careers. Multi dimensional ranking and stratification is the need of quality quantification for the institution and barriers to quality in life and work are discussed here.

Natarajan has talked on the notion and concept of quality evolution from its first application to the manufacturing sector through the service sector and the software sector to the education sector. The essential features and characteristics of quality engineering Education have been identified. The possibility of quantification of academic quality has been hotly debated among the academics. The Accreditation initiatives of NBA of AICTE have been described and discussed. There are some intrinsic barriers to Quality in a developing country like India, and these are enumerated.

In his article he stressed upon the continuous analysis and refinements of methodologies. Quality has assumed prime significance in the education sector in recent times. Perceptions of quality vary among the different stakeholders. While there are uncertainties, inaccuracies and inherent difficulties in the evaluation of research, decisions relating to its quality and value have to be made. Continuous analysis and refinements of methodologies are required in order to improve the reliability and validity of the results. Teaching quality and other features of education activity are also important.

Sahney [50] has done a comparative study of selected institutions imparting professional education to arrive at the design characteristics of TQM in education in India. Starting with a theoretical background, an empirical study is presented with analysis and results. In her article on design characteristic constructs of TQM in education she said that quality issues, and more specifically the TQM approach, has no longer been confined to manufacturing businesses and a few service businesses, but have spread to the education
sector. With the educational institutions finding themselves in a market-oriented environment, with demands from a variety of stakeholders, a ‘Customer Focus’ cannot be ignored. Not oblivious to the need for adaptation to serve the interests of its stakeholders, in terms of greater responsiveness, responsibility, accountability and increased expectations, the educational system has been pressurized to shift its focus from one on quantitative expansion, to one on emphasis on quality.

Keeping in view the relevance of total quality management in education, it is important to identify the various quality dimensions or design characteristic which if adopted by an educational institution can lead to quality in education.

In her article she talked about the quality dimensions, identification of the design characteristics reflecting the quality components for education, determination of the level of importance (relative ranking) assigned to different characteristics. In hypothesis testing on design characteristics it was found that characteristics are universal to effective and efficient organizational functioning and further need of detailed study on quality dimensions was felt.

Varghese [51] has written a technical paper on ‘Large Volume Assessment of the Quality of Higher Education Institutions’. In her paper she expressed that there is a need for large volume assessment in education sector for upcoming countries. Quality of higher education is assessed in different ways depending on the purpose of assessment, whether it is for ascertaining the quality of the program per se or the overall quality of the services provided by the institution or the performance level in terms of teaching learning processes. She talked about two types of assessments institutional assessment and program assessment. The institutional assessment deals with the institution as a whole and the latter deals with the programs it offers, in different disciplines. For countries where quality assessment is a new phenomenon, it has to start with the institutional assessment which deals with the academic, research, infrastructural facilities and the administrative and governance dimensions. She pointed out the requirement of large volume assessment in education sector required for countries like India. Also it was felt that if all institutions undergo assessment, then they will be aware of their quality status and make the incremental changes to climb up the ladder of excellence. She has
suggested two stage assessments of the institutions one is on-line assessment and second is process and outcome oriented assessment out of which second was given more stress and importance. In this article she has given one example to try out radar diagram which will have more usability for large volume assessment of data.

Jethi & Kumar [52] both of them have written article on the topic ‘Assessing Effectiveness of Teaching through Student Rating: A Study.’ This study was done by them for the agricultural university and agricultural education in India. The human resource developed in agriculture education system has been instrumental in agricultural transformation in the country. However, the agricultural education system has not kept pace with the rapid technological development taking place globally.

They pointed out the need for four core activities that affect agricultural education are quality teaching, quality of examination process, quality of faculty development for improved teaching effectiveness and quality of courses which needs to be evaluated to facilitate better learning among students. Teaching is the heart of education. A few Indian studies have also been conducted to identify various skills involved in teaching process. These studies suggest various teaching skills like introducing the topic, questioning, dealing with answers, stimulus variation, use of teaching aids, reinforcement, use of illustrations, lecturing, encouraging, group discussion, planned repletion, teaching liveliness.

They talked about the characteristic of efficient teacher. It is known that an efficient teacher is one who aims at transferring knowledge and skills to the students to compete in the job market and pursue a respectable living. A successful student is one who develops skills and an acceptable personality. They also said that in last few years the scenario has changed. An efficient teacher is one who acquires a key position in the university administration and a successful student is one who scores good marks in the formal examination. Efforts to improve the quality of teaching depend for their effectiveness on the availability of accurate, detailed and objective evaluation of teaching. The public views teachers' evaluation as a major problem in the education system today.

In their study it was expressed that teacher should excel as professionals. Teacher should also consider teaching as a noble profession which has its own ethics and dignity. Cordial
relationship should be established with students who are the direct beneficiaries of teaching. Feedback from student rating can lead to improvement in teaching effectiveness. Although student rating are an important source of data for the evaluation of teaching merits, student rating should not be the only source but can be taken as one of the important source.

Chakrabartty & Gupta [53] has done work on formulation of quality index in education. The work describes various methods of combining a finite number of quality parameters to a single index to reflect quality in education, and thus provides a solution to the much-needed problem of quantitative measurement of quality. Various methods of arriving at the single index have been described. The properties of the Index have been discussed and empirical verification regarding computation of the Index has also been done.

They have also expressed the need for improving the sagging bottom line and acceptance of challenges to increase quality cannot be over emphasized. Hence, our education system must endeavor to achieve excellence especially when competition is already being felt. The National Policy on Education of the Government of India, formulated in 1986 and updated in 1992 inter alia aiming at compulsory education for all children, has reiterated the need for substantial improvement in the quality of the education system. Accordingly, our education system needs to be Committed, Competent, Cost effective, Customer/Stake-holders oriented. Hence, there exists a need to focus on quality in education and a need to measure the quality.

In the said technical paper various methods of measuring quality as a function of chosen quality variables have been discussed. Attempt was also made to have a theoretical comparison among proposed methods. The geometric mean approach has the desired properties and avoids calculations. But for the calculation and reliability of data one will have to work on variance - co-variable matrix or correlation matrix.

Bagnlkoti et al. [54] have written on ‘Students' Perception of Quality in Higher Education - A Case Study’. In this paper they have talked about concept of quality in higher education and the work has been carried out by using ‘College Student Experiences Questionnaire (CSEQ)’. The work has been done for the admission, teaching, infrastructural facilities and employment information for the students.
It is said by the authors that the perception about quality changes from person to person. Society, government, parents, providers, employers and students have their own perception about the quality of higher education.

Authors have argued that due to wrong selection process, even the disinterested may enter the course thereby diluting the interest of other students too. The course structure is not rigorous enough to provide necessary skills to the students or involve them more completely in the learning process. Attention has been paid by the institute owners for the infrastructural development but it has not kept pace with the growth in student number.

Based on the study done following few suggestions were offered by the authors to improve the quality in education

- The academic development must be in tune with the needs and fulfillment of expectations of learners, teachers, parents, employers and society in general.
- Continuous internal assessment should be given due attention
- Appropriate and effective feedback mechanism should be established
- Assessment of the teachers by the students should be practiced for making teaching more effective and accountable.

Bhattacharya [55] has done the work on ‘TQM in Engineering Education through Meaningful Student Evaluation and Faculty Appraisal’. Author has discussed that growth in Engineering Education in India has led to the problem of maintenance of desired quality. While TQM techniques can be tried in education by taking a holistic view of the system, the critical components of the system, viz faculty development and, the student evaluation system need to be given priority.

Author has said that since the availability of training seats have always been less than the demand, the management of engineering education, although talk about quality is, by and large, not very serious about it. It is also suggested that ‘System Approach’ for the education process shall work for achieving total quality.

Sahney et al. [56] have made contribution in the area of ‘Developing a Quality Framework for Educational Institution in the Indian Context’. With ‘Effectiveness’ and
‘Quality’, both being essential to analyzing the performance of an educational institution, author has given information on various models, frameworks and approaches developed and proposed. With an emphasis on two of such models, viz., the process and satisfaction models, an attempt may be made to apply the systems approach at developing a quality framework for educational institutions. Starting with a theoretical background, the paper has presented the results of an empirical study conducted on the administrative staff, so as to obtain the internal customer's perspective on quality. The SERVQUAL was applied to identify the gap and determine the level of service quality. Following this, the quality function deployment technique was applied to identify the set of minimum design characteristics/quality components that would meet the requirements of the administrative staff as an internal customer. It is focused that the adoption of such a framework in educational institutions would lead to the creation of an environment where the administrative staff would be satisfied and in turn, be able to deliver quality service to the other customers and stakeholders.

Gap analysis was done by the author to express the gap between the expectation levels and the perception scores of the administrative staff as an internal customer. Thereafter, the quality function deployment technique was applied to identify the minimum set of design characteristics which will be able to meet the various customer requirements. These design characteristics are the parameters which when implemented, would help meet the requirements of the administrative staff as an internal customer, and thus these parameters may be used to develop a quality framework for education.

Debnath et al. [57] have written article on ‘Graph Theory Approach for TQM Evaluation of Technical Institutions’. In this they have worked on graph theory and matrix approach for analyzing system. Graph theory is useful in analyzing the interactions or interrelation of various factors mathematically.

Authors have said that presently bodies responsible for technical education in India have already started assessment of engineering and technological institutes. The AICTE is evaluating procedure for accreditation. Accreditation is a process to determine whether the institution meets the threshold quality criteria and satisfy the minimum educational criteria. However, the regulatory mechanisms of AICTE are not alone sufficient to ensure
quality of educational institutes. The assessment of the total system in terms of designing of various programs and delivery of the same, customer satisfaction, addressing research and service quality could lead to quality education. With multiple challenges like increasing tuition fees, ever increasing enrolments, changing profile of the student’s etc. authors have tried to use Graph theory approach to develop a framework for TQM evaluation of technical institutes. The framework prioritizes the interest and the requirements of various stakeholders in TQM evaluation.

Authors have pointed out that industries are mainly concerned about the relationship between customers and suppliers and how to increase the customer satisfaction by improving the services provided by the suppliers. However, in education system, the students, alumni, prospective employers, parents, society share the same characteristics of customers even though they are segregated into internal and external categories. Parameters considered by the authors in their study are infrastructure, Systems and Policies, faculty, curriculum and stake holders’ satisfaction.

Bansal & Chandwani [58] have presented on ‘Process Knowledge Maps for Academic Excellence’. They talked about a problem of requirement of managing the knowledge in an academic set up. Their focus was on development of process knowledge maps. Authors have said that the academic infrastructure is passive and does require intellectual inputs of the stakeholders for speedy outcome and consistent supply chain. The process knowledge maps deal with the passive models and attempt to make them active and dynamic. They have presented an intrinsic model of process knowledge maps, a multilevel hierarchy.

They have presented a stepwise development cycle with illustrative schematic of producing k-maps of different requirements. For the fully developed system there will be interlinked maps for all the processes within an organization. Presently, the model is at conceptual stage and is subject to undergo formal design, architectural design and implementation towards automating the system.

Rao & Pandi [59] made important contributions through their study on the topic of ‘Quality Enhancement in Engineering Institutions through Knowledge Management and Total Quality Management’. 
Authors have given stress on the management of knowledge in businesses and its importance and necessary factor for organizational survival, and to maintain the competitive advantage, organizations need a TQM approach that views knowledge as a potential source of competitive advantage. Knowledge Management (KM) can be viewed as the process of identifying, organizing and managing knowledge resources. Authors have pointed out that there are only two things (KM&TQM) that need to be practiced in order to achieve excellence in engineering education. Authors have expressed that an educational institution becomes a centre of excellence only through the concerted and collective efforts of all the stakeholders and also employing continuous quality improvement tools.

Kulkarni [60] in his article on ‘Centre for Innovation in Engineering Education’ has said that the higher education system in future can survive only when higher education brings professionalism in its functioning. Author has pointed out the need for reengineering of the organization structure in the traditional institutions for the continuous progress of the organization in terms of quality.

Gole & Jolhe [61] have made contribution through the article on ‘Human Input Measurement Methodology for Engineering Education’. They have made an attempt toward the development of a methodology for the measurement of performance levels of the teacher's attributes as the input parameters. The paper has provided important guidelines to all those who are concerned with evaluation & performance improvement of the engineering education.

Authors have tried in applying measurement methodology for evaluation of knowledge attributes of the teacher such as knowledge, skill, performance and behavior. The methodology suggested helps to evaluate the performances of the teachers objectively.

Naik & Kandlikar [62] worked on ‘Gap Analysis between Indian Institutes and their Counterparts Abroad’. In this paper authors have discussed many points about the quality of higher education in India. The author raised several questions: Where does India stand in the world list in higher education? Why thousands of students every year go abroad for advanced learning? What do they teach which we do not? How are their institutes different from Indian? Where do we go wrong?
The article presents in brief, the gap analysis in respect of visions and missions; policies and practices; organization structures, systems and procedures in India and their counterpart institutions in developed countries. Authors have said that IITs were set up under foreign collaboration. Their visions, missions, policies and practices are molded on global lines. Hence they could shine. The gap analysis presented here makes an attempt to find answers to the questions raised above. In conclusion, they have remarked that Indian institutions and universities need to have world class vision to enable people to grow. Creation of favorable environment for the same should be our top priority. There is nothing more urgent for India at this juncture of time than reviving higher educational institutions and upgrade them to international level.

Modak [63] has said in his article ‘Research Orientation to Engineering Education’ that involvement of a teacher in a research activity helps him in becoming a qualified teacher in a real sense of the term.

Gupta [64] has written a technical paper on ‘Audit the Vision of Your Institution’

Author has said that the vision statement indicates the future intents of the institution say after 10 years what it wants to achieve in terms of customer satisfaction. It is expressed in future expectations of the customers and employees. It provides a clear picture of the destination of the institution. Many institutions are expressing it in quality and value loaded terms. The vision is never constrained by current limitations, capabilities and capacities of the institution. Generally, the vision of the institution is constant but it forces the institutions to design dynamic strategies to achieve it. Author has expressed that the vision audit is a powerful tool to review the process of visioning and quality of the vision of the institution.

Joshi et al. [65] have researched on, ‘Management of Students Performance in Engineering Education: An Analysis’. In this paper authors have shared their experience about the effect of meditation on the Analytical power, Memory power, Concentration and Examination Performance of an engineering student. It helps in improving the performance of an engineering graduate.


2.7 Industry Expectations and Engineering Education

2.7.1 Industry Needs and Expectations

Industry's enduring interest lies in targeted development. Large-scale industry has the resources to invest in new technology development initiatives, but it often tends to rely on bought out technologies, generally from the overseas. Academic intervention may be required in minor technological innovation/modification aimed at technology absorption/implementation.

In the case of medium scale industry, the needs are primarily oriented towards problem solving, with support required in the areas of design, process improvement and plant and machinery performance, etc. This industry segment may also need academic intervention in reverse engineering where the product exists and what is sought to be developed is a process to yield it. There may be some appreciation, specifically in the case of medium scale industry, of the need for parallel exploration of a new product line triggering a focused developmental activity, which might be carried out in-house or in collaboration with the academia.

Small scale industry dealing with specific products or ancillary units acting as feeders to medium or large scale industry does not generally seem to have development driven needs. In this case, problem solving may simply amount to product testing and production enhancement in terms of quantity and quality.

In its interaction with the academia, industry's expected time frames are immediate, and investment is directed towards efforts that promise result-oriented solutions. The costing frames are typically guided by a reluctance to invest in technology R&D that has either long term or unclear outcomes.

The gap between industry's needs and the academic community's aspirations appears to be considerably large. There exists a strong feeling, at least in the academic circles, that unless technology driven initiatives find a surer place in the industrial sector in this country, the academia-industry interaction is likely to remain confined to developmental activities with limited exploratory or research-based content. With little or no acknowledgement of research-intensive needs on the part of industry, and the marginal
interest that purely development related activities evoke amongst the academia, the academia-industry interaction does not appear to be resting on very firm grounds. Moreover, there appears to be a critical mismatch in relative perceptions of the two on the issue of how technology development is to be achieved. For academia, technology development amounts to conceptualization and execution coupled with validation at the laboratory level. For industry, the interest lies in translating the laboratory-validated concept into a commercial proposition, where the most important considerations are those of economic viability. The industrial R&D in the country should actually be focused on this phase of technology development where laboratory models are scaled up and converted into commercially viable products/processes. Evolving a laboratory-proven idea into an implemental technology is a kind of effort, which the academic community does not appear to be fully geared towards, at least at present. Should the academia be at all involved in such an effort? This is a question we need to confront keeping in view the possibility that academic potential is best exploited in the first phase of technology development.

2.7.2 Problems of Engineering Institutions

In India, the educational institutions in general are concerned with teaching knowledge and related skills. This is true for primary to higher education. Researchers have claimed assumption that research is prestigious but teaching is not so. It is good to have a few institutions that are strong in research but we should have all the institutions strong in teaching. Good research should be encouraged but it should not be at the cost of teaching. Therefore the NAAC gives a prime place to quality of teaching learning and related aspects during assessment of institutional performance [48].

Good faculty and good systems are two key success factors enabling better performance of the system. Good faculty with poor system feels handicapped while good system with poor faculty quality does not achieve optimal performance [19].

2.7.3 Non-availability of Competent Faculty

With the rapid growth in the number of engineering institutions, non-availability of adequate number of competent faculty has emerged as a serious problem. Faculty shortages have been seriously undermining the quality of technical education.
2.7.4 The Mission and the Objectives of the Institutions

The success of any quality assurance initiative is greatly dependent on the managerial factor. It is essential that the top management be totally committed to the concept, to be able to visualize future actions in their totality, and design appropriate procedures. This means that the mission of an institution should be clearly defined, its long-term and short-term objectives precisely identified. The strategies for achieving these carefully planned, adequate budgetary controls are exercised, and inter-personnel relationships maintained at an optimum level. Self-evaluation is usually the starting point with the main objective being to identify areas of strength and weakness for the institute. Evaluation by stake holders and peers clearly bring about directions for continual improvement.

It is often argued that for the successful implementation of quality assurance measures the concept of TQM should be applied in educational institutions. However, the application of TQM techniques is not likely to be easy in higher education institutions for an essential requirement would be significant cultural change - from the present collegial culture to the enterprise culture of business [26]. It involves change in mindset.

2.8 Motivation and Objectives behind Present Study

With the never-experienced growth quantity-wise, engineering education today has a great concern about excellence and quality in engineering education. The overall investigation, therefore, aims at a comprehensive study and evaluation of some of the critical parameters which are affecting the growth in terms of quality and excellence in engineering education.

The studies which are made so far are limited to mainly and largely about quality theory and little analysis and hence efforts are made to study quality measurement aspect at micro level. Details of these studies are given in the next chapter on ‘Methodology’.