# Chapter 3

## TOTAL QUALITY MANAGEMENT

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TOTAL QUALITY MANAGEMENT APPROACH

3.1 Total Quality Management

Total Quality Management (TQM) is the future of doing businesses. Initially, people used to follow the traditional way to do the businesses. TQM is just the advancement of the businesses with the help of world class ideas and philosophies. TQM suggests changes in action of management and culture of the organization. TQM is not more than common sense. TQM is effort to provide excellence in the processes, management activities and thinking of every employee of the organization, which ultimately excellence in products and services.

Analyzing the three words, we have

Total – Made up of the whole

Quality – Degree of excellence a product or service provides.

Management – Act, Art, or manner of handling, controlling, directing, etc.

TQM is defined as foundation for the organization with the help of guiding principles and proved philosophies. TQM is an application which helps to improve quality as per the expectation of the customers and ultimately leads to overall increase in revenue of the organization. TQM changes the traditional definition of the quality and force to understand what the customer requires in new marketing environment which changes in few days or months.
3.1.1 History

Japan is the country which has implemented this concept first time in their businesses. In 1950 Japan was in big crunch with no natural resources and no reputation for the products in the markets. But this worst situation gave birth to new idea of quality, that is, TQM.

This new approach was totally different American approach to quality. American traditional approach was based on the manufacturers understanding about the market and its implementation in the products. But this new approach was based on customer’s expectations about the products and its implementation by the manufacturers.

Toyota is the best example of TQM [2]. The great success of TQM then forced to implement in American companies like Ford Motors. Unfortunately, most of the American companies failed to implement TQM.

The need had arrived to understand the quality management concept with the new era and differentiate it with the traditional approach of quality control, which was actually left by the Japanese industries so many years ago and which is misunderstood by the American Industries. Walter A. Shewart and W. Edwards Deming, are the first non-Japanese taken efforts to understand the new definition of quality and open the new world of business.
3.1.2 Traditional Approach to Quality Control

Quality Control is an important concept for every organization where the specifications of the products are required. This is not only important for sales but also for every department of the organization. The quality control has following steps:

1. Produce the product with major emphasis on cost and quantity.
2. Measure the product after it is produced to determine whether it meets product specifications.
3. Ship products meeting specifications and reject products not meeting the specifications.

Traditionally, quality control was considered as the concept for higher marginal profits. Quality control was considered as the tighter control over the processes and the productions. Tighter control was expected to increase productivity.
3.1.3 Quality: A Non-Traditional Approach

To manage the total quality, one needs to understand the meaning of the quality first. Quality has different meanings based on the requirements and perception of different people.

Perceived quality is based on the attitude of the people, thus the level of satisfaction changes and the perception of the performance also changes. It also differs on the objectives of the product to purchase.

Quality can be defined as the degree of -

1. Excellence
2. Value
3. Conformance to specifications
4. Meeting customer’s expectations.

The first two are subjective concepts and last two are the objective. The last two are easy to apply, manage and measure the products and services. But first two are very difficult for everything. When quality is considered as the excellence in the products or services, then it is generally considered for the expectation in price [48]. So the conclusion is the definition of the quality varies with the definition of approach and conditions [49].

For example, Nirma washing powder has the largest penetration in rural region of India. The definition and the expectation of the rural customers are completely different than the urban customers. And one cannot neglect these expectations of quality of the rural customers of a country like India where 70 percent population resides in rural region. So that people are not wrong and the need arise to broaden the definition of quality.
One consider the quality has achieved when a product achieves the customer expectations. Quality can quantify by the equation:

\[ Q = \frac{P}{E} \]

Where \( Q \) = Quality of a Product  
\( P \) = Performance of the Organization  
\( E \) = Expectation of the Customer

This equation clearly shows that quality of the product is assumed to good when the value of \( Q \) will be more than 1.0. Of course, it will be more than 1.0 unless and until the performance of the organization will be more than expectation of the customers. Ultimately, this equation proves that, the performance of the organization should be always a head of the expectations of the customers and organizations should be able to predict the future requirements to satisfy the current needs of the customers.

Variation is also one of the most important problems to maintain quality. It makes the quality poor. If the manufacturer wants to maximize the quality, they should concentrate to minimize the variations. TQM reduces variations in every aspect of company processes.
3.1.4 A comprehensive framework of TQM

According to Scholtz, the evolutionary development of the quality concept can be regarded as a continuum consisting of three different stages/phases in the development of quality, each one separated by a substantial paradigm shift in the thinking approach of quality, namely[51]:

(1) quality of product,
(2) quality of organization and
(3) quality of life.

Figure 17: A comprehensive framework of TQM
With reference to figure, quality was originally achieved by inspection – screening out defects before customers noticed them. The quality control (QC) concept developed a more systematic approach to detect quality problems.

Quality assurance (QA) widened the responsibility for quality to include functions other than direct operations of an organization.

Some of the important benefits of TQM are:

- Fulfilling the customer expectations
- Cover every process and department of the organization
- Consider every employee as a customer to organization
- Guides to quality procedures to help in improvement process; and
- Quality is consider as a continuous improvement process
3.1.5 Principles of Total Quality Management

The others who elaborated on this include

Present TQM is the final product contributed by three management Gurus namely Deming (1986), Juran (1951) and Ishikawa (1964) [53]. They made the pillars of the successful implementation of TQM.

1. **Customer focus:** The first judge of the quality is customers. Customers can be external, that is, outside the company or internal, that is, the employees of the own organization.

2. **Obsession with quality:** The organization should select resources, distributors, employees, suppliers, everything on the basis of quality and not the cost. Every entity of an organization must work collectively towards achieving the quality.

3. **Teamwork:** Teamwork of every employee and participants of the products is essential to achieve the targets. Cross-functional teams performs major role to solve quality problems. Quality circle is one of the best examples of it.

4. **Statistical Methods:** The use of the statistical methods with the awareness of the objectives minimizes the variability. The scientific methods helps to monitor the performance.
### 3.2 TQM Characteristics and Sub-characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Sub-characteristics</th>
<th>Meaning of a Term</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Suitability</strong></td>
<td></td>
<td>specification of the functions of the software which is more suitable and comfortable for a specific purpose</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td></td>
<td>This refers to an ability to give correct results and outputs for which it is manufactured</td>
</tr>
<tr>
<td><strong>Functionality</strong></td>
<td><strong>Interoperability</strong></td>
<td>A given software component or system does not typically function in isolation. This sub-characteristic concerns the ability of a software component to interact with other components or systems.</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td></td>
<td>This refers to an ability where the software is considered to be secured from unauthorized access, viruses, loss of data, etc.</td>
</tr>
<tr>
<td><strong>Client Support</strong></td>
<td></td>
<td>Navigation in an E-Commerce shop is similar to a walk in a real shop, where the user interacts with the seller</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td></td>
<td>The extent to which the web site is accessible to users through different browsers in different times</td>
</tr>
<tr>
<td><strong>Understandability</strong></td>
<td></td>
<td>It refers to an ability of the software or product about how effectively it recognizes the request fired by the user to give correct results.</td>
</tr>
<tr>
<td><strong>Usability</strong></td>
<td><strong>Learnability</strong></td>
<td>It refers to an ability of the software or product of how users can easily learn it to use.</td>
</tr>
<tr>
<td></td>
<td><strong>Operability</strong></td>
<td>It is a measure of probability that the system will be stable and won’t fail to complete intended function.</td>
</tr>
<tr>
<td></td>
<td><strong>Attractiveness</strong></td>
<td>pay attention on various types of interfaces by which users can differentiate the usability of every feature separately.</td>
</tr>
<tr>
<td><strong>Time Behavior</strong></td>
<td></td>
<td>Time needed to elaborate and execute the requested functions in agreed conditions.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Behavior</td>
<td>Resource Quantity and type of resources used to execute the requested functions</td>
</tr>
<tr>
<td>------------</td>
<td>----------</td>
<td>-------------------------------------------------------------------</td>
</tr>
<tr>
<td>Purchase Process Performance</td>
<td>To promote fair and open competition for their business while minimizing exposure to fraud and collusion.</td>
<td></td>
</tr>
<tr>
<td>Page Generation Speed</td>
<td>Allow to conclude on the users’ minimum efforts to generate the required web pages with high speed.</td>
<td></td>
</tr>
<tr>
<td>Maturity</td>
<td>which prevent from failures by measuring the frequency of faults occur in a system.</td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td>Fault tolerance</td>
<td>The ability of software to withstand (and recover) from component, or environmental, failure.</td>
</tr>
<tr>
<td></td>
<td>Recoverability</td>
<td>refers to an ability of software or product to recover from fault or any unwanted interferences</td>
</tr>
<tr>
<td>Maturity</td>
<td>Analyzability</td>
<td>Characterizes the ability to identify the root cause of a failure within the software.</td>
</tr>
<tr>
<td>Maintainability</td>
<td>Changeability</td>
<td>Characterizes the amount of effort to change a system.</td>
</tr>
<tr>
<td></td>
<td>Stability</td>
<td>to remain stable in the system, an indication of response to system in harsh environment</td>
</tr>
<tr>
<td></td>
<td>Testability</td>
<td>to validate the results and covers all types of tests.</td>
</tr>
<tr>
<td>Adaptability</td>
<td>Adaptability</td>
<td>about how well it adopts the changes in the environment.</td>
</tr>
<tr>
<td>Portability</td>
<td>Installability</td>
<td>Characterizes the effort required to install the software.</td>
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<tr>
<td></td>
<td>Co-existence</td>
<td>Characterizes the ability of a system to either handle increases in load without impact on the performance of the system, or the ability to be readily enlarged.</td>
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<tr>
<td></td>
<td>Replaceability</td>
<td>how well anybody, any time can replace one software or a part of it without affecting system processes.</td>
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</tbody>
</table>

**Table 4: TQM Characteristics and Sub-Characteristics**

73
3.2.1 Functionality

The functionality is an ability of the software or the product to give maximum output any time of working. Functionality achieves the purpose of the software or product requirement. Functionality is the highest level of expectation about the product where customer gets the confidence that every feature of the product will be at least in working condition.

When customers access internet or E-Commerce websites, the navigation creates the impression that every feature is providing correct information and it will provide compatibility in purchase procedure [56].

Functionality is having following sub-characteristics:

3.2.1.1 Suitability
3.2.1.2 Accuracy
3.2.1.3 Interoperability
3.2.1.4 Security
3.2.1.5 Client Support
3.2.1.6 Flexibility
3.2.1.1 Suitability

Suitability is an ability of the software or the product by which it will be more suitable and comfortable for a specific purpose. Suitability finds maximum appropriateness of the attributes in the product or software for defined task. Suitability is an ability of a search engine to provide correct information at right time.

Suitability in the web applications is the need of today’s environment[57]. Most of the time, it is very difficult for the customer to go through his actual choices on the homepage. Just because of lot of promotions, websites always try to show everything on the homepage. If some stocks are not available to company, then company should remove that content from homepage.

Some websites purposely slow down the buying process of customers by showing 10 recommendations expecting that the customer should get the information of their other products also. But if customer has a short time and he gets frustrated, then he might just leave.

The E-Commerce companies always forget that quality can’t be defined as high or poor. It is the combination of all inherent features of the products or service. The suitability in the look, simple information, and short purchase process of the product is considered as the quality in terms of customer.
3.2.1.2 Accuracy

Accuracy is an ability of a software or product to give correct results and outputs for which it is manufactured. Accuracy is the extent to which data are exact, correct, and valid. Accuracy is the provision to provide information by text, pictures and videos about the product.

For example, accurate data affect a program’s ability to provide reliable transaction rates and to maintain data comparable to those from other programs. Accuracy reflects the program’s standard to conform to agreed-upon case definitions and requirements[11].

PricewaterhouseCoopers conducted the survey of 599 companies to check the estimates of the poor data. It shows the cost of poor and incorrect data is around 15% to 25% of the products. Many times the companies don’t get the root cause of the big loss or failures. Accuracy in the data is the fact which companies use to underestimates.

Most of the companies can believe that the others have a larger problem than they do and assume that the photographs or the text is similar to the products they are going to deliver.

This is found that the quality of the data is considered as a small problem and employees give preference to other serious problems. But they forget that data is the last thing which changes the mind of the customers. This difference in accurate information looses the faith of the company in the mind of the customers as well as creates problems in the business transactions also.
3.2.1.3 Interoperability

Interoperability is an ability of software or a product to operate successfully as a part of a system. Interoperability is an ability to communicate successfully with one or more systems and exchange information internally or externally to the system with the help of specific formats and protocols [58].

But it is not just a technical matter of connecting computers. But it also helps to share the information between networks and the re-design of business processes to deliver improved outcomes and efficiencies and to support the seamless delivery of company services.

TQM suggests interoperability as a fundamental to the success of connected company - the aim for collaborative, effective and efficient company and the delivery of seamless company services[59]. Interoperability is an important element in the delivery of company service reform and integration initiatives.

It should understand that:

• it is the capability to connect systems
• it follows standards, which helps to communicate systems with differences
• it helps to maintain social and cultural context of the organizations
• it is an ongoing process for the existence of a system.
3.2.1.4 Security

Security is ability where the software is considered to be secured from unauthorized access, viruses, loss of data, etc. Security is an assurance of the safety against accidental or unauthorized use.

Security provides conformance about security features of the product by which it won’t create any problem to users as well as other parts of the system. Anti-viruses are the best examples of it[27].

The Deming fourteen principles are also based on security [2]. It provides all guidelines of security measures which organization can follow to remove security threats. Security is an ongoing practice. It makes lack of faith between users and management. The fact is that there is no cost for the security. Security is the process of inspection.

But it is also the efforts of improvements in operations and processes. Though inspection is accomplished to security, but the ultimate aim of the security is to minimize variations which can be created by mistakes and new opportunities.
3.2.1.5 Client Support

Client support refers to an ability of software or product by which it provides conformance of defined standards and the laws specified in description.

Customer always expects support in navigation, customer care, maintenance, etc which is applicable to E-Commerce shops also. Customer wants to interact with the sellers like traditional way. He expects the answers of simple questions which can satisfy his dilemma.

The Institute of Management Services has given the definition of Total Quality Management as: "A strategy for improving business performance is depend on commitment and involvement of all employees of the organization which leads to satisfying requirements of customer, overall reduction in cost, and continuous improvement of the products and services [2]."

Client support is also one of the debated issues for E-Commerce companies [25]. Online companies take the misuse of personal data of the customers. Customer data is the major asset and how to use it for the support is very serious privacy issue. The purpose of the customer data is to facilitate more options for the benefits of the customer. Companies try to survive in competitive environment and to increase the revenue through the personal data of the customers [25].

The Platform for Privacy Preferences Project (P3P) is client support privacy technology which automatically blocks the access of unwanted users [25]. TQM provides the facility of “personal consumer information cost (PCIC)”, to study the personal information of the users.
3.2.1.6 Flexibility

Flexibility refers to an ability of software or product to give maximum performance to the resource used to satisfy customer changing demands.

Flexibility is the extent to which the website is accessible to users through different browsers in different times [27]. In the recent trends, outsourcing is the best example to satisfy the customer demands. It helps to maximize the speed of customer service for ever changing customer expectations.

The customer is not interested in what the company wants to sell, but the customer is interested in what he wants to purchase. Here the E-Commerce companies miss to find out the flexibility in demand of the customer.

Companies should have the flexibility criteria to find out not only the present demands but also the future demands of the customer based on changes in expectations. Even the market decision makers expect flexibility in the systems which will quantify the abstractions of customer data and reduce the variations [60].

Since 1980, the Atkinson’s “Flexible firm” model is performing an important role to reduce the rigidity of the market and is providing flexibility in decisions. It helps to find the labor requirements in the market by differentiating in full time employees, part-time employee and workers. It provides functional flexibility to find lower jobs as well as special skills require completing one task. Iren Gyoker and Henrietta Finna in “Social Domain” provides the guidelines how to apply the flexibility in the organization [61].
3.2.2 Usability

Usability refers to an ability of the software or product about how effectively it understands and learns the requirements of user and provides maximum uses of resources for the benefit of the customer for which the product has made.

Usability is the set of attributes which is implemented on the basis of customer assessment in the product and maximum output for which it is purchased [27].

In E-Commerce usability is not only an issue to provide operational benefit to customer but also it helps in development process and maintenance of the product.

It provide solution to so many issues of users like -

1. High level interaction to complete one task.
2. Wrong sequence of steps for interfaces.
3. Data is not properly grouped.
4. Unavailability of problem solving methodologies or techniques.

The Usability has following sub-characteristics:

3.2.2.1 Understandability
3.2.2.2 Learnability
3.2.2.3 Operability
3.2.2.4 Attractiveness
3.2.2.1 Understandability

Understandability refers to an ability of the software or product about how effectively it recognizes the request fired by the user to give correct results. Usability is a characteristic of software quality which means ease of understanding software systems [62].

E-Commerce helps to develop smart processes to understand the changing environments. Most of the software industries just concentrate to deliver the products, but sometimes they forget to understand the quality attributes of the software.

Sometimes software developers make a best quality software, but they forget to provide best documentation which is the communication link to understand the software. The formula for the understandability is very simple. If the company expects, the customer should learn something about the product, it should provide proper understandability in software by documents, tooltips, help, comments, etc[63].

TQM refers the solution for the problem of understandability. It provides the guidelines of the necessary activities in the processes by which the documents become more understandable to users. To increase the organizational performance, it is necessary to understand customer requirements.

TQM suggest so many techniques like Ishikawa diagram, flow diagram, house of quality, etc to understand user requirements. It purely stress on the inputs and outputs. These methods include careful questioning of expectations and help benchmarking team to ensure the changes.
3.2.2.2 Learnability

Learnability refers to an ability of the software or product of how users can easily learn it to use. Learnability is an ability to applications which helps to complete the process without wasting time and frustrating to users.

A recent study found that, user loose 43% time on internet or E-Commerce activities just how to learn the process. They face the problems like hard to find next step, missing data and interference of unwanted features and they just prefer to leave the process [64].

Furthermore, learnability is also very important for usability. Lack of proper learnability features in software doesn’t give full benefit to usability. The organization invests huge money on creating features in the software. But if the user is not using all the features then ultimately, this is a loss of the organization.

TQM guidelines to learnability [65] –
(1) Increase value of customers by implementing new products and services;
(2) Develop new opportunities;
(3) Try to reduce defects, errors, waste, costs, etc;
(4) Improve response and cycle time performance;
(5) Increase productivity by full use of resources; and
(6) Increase company performance with responsibilities to users.

Learnability is the answers of the following questions of manufacturer, like -
- Is there a gap between company performance and the performance of the best-in-class companies?
- What is the gap? How much is it?
- What are the reasons of gap? What are the solutions to it?
3.2.2.3 Operability

**Operability** is a measure of probability that the system will be stable and won’t fail to complete intended function.

Operability refers to an ability of the software or product by which it should be operational in the specific environment. Operability also includes control of processes.

Operability refers to use-friendliness which specifies the software capability to user interface to provide full support in required procedures. User should get easy access to virtual shop through any website which they generally use to like rediff, yahoo, gmail, etc.

Some of the issues of Operability are:

- The system crashes or becomes unresponsive.
- Output is inconsistent.
- Unable to fetch the data from external systems

If the user faces these types of problems then user response decreases immediately. TQM helps to find ways to handle communication problems, unwanted external systems, etc.
3.2.2.4 Attractiveness

Attractiveness refers to an ability of the software or product to contribute and navigate the usability features. Attractiveness is to pay attention on various types of interfaces by which users can differentiate the usability of every feature separately.

Attractiveness is the biggest opportunity in the market which differentiates a product and product design to show more advantage compare to other products. It creates wide varieties of appearances to help the choices for the customer. First appearance of the product or the software performs most important role on customer evaluation of products.

Attractiveness of web sites creates a big impact on consumers with respect to presentations, such as pictures, animations, etc. An aesthetic or symbolic appearances in the product helps to communication the functions and ease to use. In qualitative study, the quality of a product always judge on the basis of how effectively the choices are described in the product [66].

TQM provides a model for attractiveness which focus on two components [67] -

![Attractiveness Model](image)

Figure 18: An Attractiveness Model
1. Customer needs
Customer is the highest authority to judge the quality of the product and not the manufacturer. Customer perception and satisfaction of quality has highest priority in purchase procedure, ownership and services offered.

2. Quality of service
TQM defines quality as a continuous improvement process which includes small or big changes in processes and leads to rapid improvements. An organization’s responsibility is to meet customer specifications beyond expectations by reducing errors and solving complaints.

3.2.3 Efficiency
Efficiency refers to an ability of software or product to give maximum performance in minimum time and resources without affecting quality. Efficiency describes the time and efforts require completing a task [56].

Efficiency also include saving waste, money and unnecessary efforts. The meaning of efficiency varies in different disciplines.

Efficiency of web sites creates a big impact on consumers[66] with respect to:
- interactive shopping pages in terms of time, click, and run-time errors
- corporate homepage navigation, such as locations of hyperlink, menus and bars

The Efficiency has following sub-characteristics:
3.2.3.1 Time Behavior
3.2.3.2 Resource Behavior
3.2.3.3 Purchase Process Performance
3.2.3.4 Page Generation Speed
3.2.3.1 Time Behavior

The time behavior refers to an ability of software of product about how well it gives maximum performance in specified time. It correlates with the time behavior of the software (or parts of it) in combination with the computer system during testing or operating and to get the information, services or products on a right time to the users.

Time is critical for successful, high-growth business. A number of software attributes are associated with the behaviour of the system across time[2]. The interactions between the various attributes are nontrivial and often involve tradeoffs. Therefore, before embarking on a project to improve the time performance of a program’s operation, it is important to determine which of the time-related attributes we want to change.

With rapid case identification, the program is able to provide timely prevention and intervention services, respond quickly to investigations, and monitor trends[11]. The most important attributes are latency, throughput, processor time requirements, real-time response, and time variability.

TQM advanced methodologies can cut development time without compromising quality. Company can develop in-house controls and scheduling systems to maintain process flow so that demanding schedules are kept on track and delivery schedules are met.

Company can maintain the systematic stepwise approach with the help of waterfall model and can make interactive framework which can reflect real world in timely manner and can help to quality deployment in the software.
3.2.3.2 Resource Behavior

The resource behavior refers to an ability of software of product about which measures the attributes and concludes about its work behavior in a system.

The resource behavior is very similar to the preparation of the food. The taste of the food changes if we change the ingredients. Just the utilization of the resources is not sufficient unless and until the product is up to the level of satisfaction of the customer with respect to all requirements in the product. A system is considered as an efficient, if the user get wide choices of data for their requirement, very similar to the physical access of a shop.

Companies are increasingly using so many methodologies to improve efficiency, increase performance and reduce cost for business processes. eBay’s Reviews and Guides is the best example where client-to-client E-Commerce site and customers often get confused between the product review portal and seller/buyer feedback profiles. In fact, feedback for sellers is often found among product reviews[20].

A resource is said to be critical to performance when it becomes overused or when its utilization is disproportionate to that of other components. How you measure resource behavior depends on the tools that your operating system provides for reporting system activity and resource utilization.

In E-Commerce, certain time spans are constant and certain are heavily loaded by transactions. It affects on the speed of work performance to the user. In particular, TQM focus on the analysis of the phenomenon to find out workload-dependent processing speeds and the changes in the resource utilization to give maximum performance.
3.2.3.3 Purchase Process Performance

The purchase process performance refers to an ability of software or product about how it gives maximum performance to satisfy the degree of purchase requirement and gives output beyond expectations. It is the extent to continuous improvement in performance.

Purchase process performance is widely known as procurement performance which is a common term used in organizations. TQM also suggests the Continuous Process Improvement (CPI) for the continuous improvement in performance. Continuous Process Improvement is a continuous approach of quality maintenance and improvement in production processes [2].

These processes help to reduce waste, time, etc. In 2011, one survey of 250 Chief Procurement Officers found that procurement department handles 60.6% revenue of the organization and CPI achieves 6.7% savings out of it. Users need more information while in the midst of completing a task; they have varying levels of subject matter and technical expertise. Companies can provide them with the content they need and not get in the way of their task completion.

The quality study addresses the ranking issue of the contents provided on E-Commerce sites. The case study of eBay shows that removing unrelated contents from site is not sufficient to give the service to the users. System should tell the users which article contains valuable information to the user, from the product review angle, and this should be done on time when the customer requires it[20].
3.2.3.4 Page Generation Speed

The Page Generation Speed refers to an efficiency of software or product to generate web pages. It relates to navigation of web pages to facilitate comfortable work environment.

Customer expects the navigation should be done in a timely manner and description of the information should be done immediately. The size of the web pages increasing rapidly. But the speed of the internet is not increasing accordingly.

E-Commerce require high speed internet. The key takeaway here is that the pursuit of faster websites is a never ending race. As pages continue to grow in size, more complexity will increase and it will become difficult to do the business.

The solution is “Just-in-Time” information which is nothing but one format in the form of layer, and helps to invoke the information without changing the meaning of it. “Just-in-Time” (JIT) helps to give the information about location, time and other in a particular way that the customer can immediately get the knowledge of access or handling the system [2].

JIT information in an attempt to lower service costs while keeping their customers happy, there are a number of challenges they face.
3.2.4 Reliability

Reliability refers to an ability of software or product to provide high degree of performance with high degree of comfort to use a system. Reliability is an extent to which it will be operational throughout the time with ease of working [27].

It is the probability of any function which anybody can count from first time to the last time to inspect a quality as a finished product [69].

TQM suggests a formula to calculate the reliability –

\[ R_s = (R_1) (R_2) (R_3) \ldots (R_n) \]

where \( R_s \) = reliability of the product or system.

\( R_1 \) - \( n \) = reliability of components 1 through \( n \)

The Reliability has following sub-characteristics:

3.2.4.1 Maturity
3.2.4.2 Fault Tolerance
3.2.4.3 Recoverability
3.2.4.1 Maturity

Maturity refers to an ability of software or product which prevent from failures by measuring the frequency of faults occur in a system.

Maturity is the criteria which creates difference of the software with the others. It is related with so many important factors like understanding the widely used applications need to be stable with required in process chains of user. Maturity is the trustworthiness of maintaining consistent reliability to protect from failure and hence helps to build trust relationship [27].

The Capability Maturity Model (CMM) is a technique which helps to refine maturity in organizational processes [2] [57]. It describes a five step approach to achieve maturity in systematic manner.

CMM’s works on next five levels:

1. The initial level
2. The repeatable level
3. The defined level
4. The managed level
5. The optimizing level
3.2.4.2 Fault Tolerance

The fault-tolerance refers to an ability of software or product to tackle a fault, to avoid a fault as well as running other functions without failure of overall system.

Fault tolerance can be managed by following two methods -
1. Defensive programming
2. Software diversity.

1. Defensive Programming

Defensive programming is the basic type of fault-tolerance where error of a software is checked repeatedly and the data use to protect from corruption. This is done by error handling processes which can be in-build itself in programming.

Sometimes a client cannot be made fault tolerant by using replication. In some circumstances, due to the unavailability of sensors or processors, the fault-tolerance face limitations[70].

2. Software Diversity

Software diversity is an intuitive but imprecise term used to express the idea that variability can improve the survivability of a population. Diversity as a mechanism for fault tolerance was put forth as n-version programming[71].
3.2.4.3 Recoverability

Recoverability refers to an ability of software or product to recover from fault or any unwanted interferences. This is an ability to re-established an initial working level of system and protect it from failure [2].

TQM suggests the guidelines to recover user transactions and data in a system glitch or power failure.

1. **Creating database backups**—Databases are vital to the recoverability of deployment.

2. **Using hardware standards**—Using set standards for hardware improves the maintainability and recoverability of deployment.

3. **Maintaining hardware records**—Keeping good records of hardware configurations and hardware parts suppliers helps make both routine maintenance and disaster recovery more efficient.

4. **Maintaining software records**—Software configuration records is an important asset to recover from disasters.

5. **Planning hardware contingencies**—Having a hardware contingency plan can help minimize downtime costs by allowing to replace hardware quickly in the event of a failure.

6. **Providing training and documentation**—Proper documentation of the systems and training of staff is vital to recover a system from failure.
3.2.5 Maintainability

Maintainability refers to an ability of software of product to undergo changes if require to provide degree of ease. The changes can be in interfaces, small features, components, etc. Maintainability is very important to fix errors and meet new user requirements.

Maintainability is a continuous activity. Senior executives are the key people to implement the quality issues with respect to get the products to the customers on time[72].

Software maintenance is always used to recover and modify the data after delivery. Maintainability is an important pre-requisite for reusable aspects and aspect-oriented systems because crosscutting concerns are very difficult to change [73].

The Maintainability has following sub-characteristics:

3.2.5.1 Analyzability
3.2.5.2 Changeability
3.2.5.3 Stability
3.2.5.4 Testability
3.2.5.1 Analyzability

Analyzability refers to an ability of software or product to find the reasons of deficiency, failure and feature to be modified.

An important element of the software’s maintainability is its analyzability. This property has two facets: When things go wrong, one wants to be able to locate the causes of the failure; when new specifications arrive, one wants to be able to locate the software parts that are to be modified. Many elements of the program’s analyzability are intimately related to the cognitive processes going on in our human minds when one tries to understand a piece of code.

Analyzability is one of the important criteria for the business. For maintainability of the software or web, the users complaints is a rich source of information[2]. Users always face so many problems. They always expect the solution for the problem. But users don’t want to know how the internal system of the organization works. They don’t want to hear the excuses to meet the expectations. Users evaluate their own experiences of E-Commerce websites based on their own criteria that manufacturers may not considered serious.

The team should take constant review how complaints have been addressed historically and then design process to maintain complaints.

This process includes:

- Techniques to collect customer complaints
- Capability to give immediate response to complaints
- Method to find the seriousness of the complaints and to find root causes
- Finds the ways to recover customer completely from the problem and this will not repeat in future.
3.2.5.2 Changeability

Changeability refers to an ability of software or product to adapt the changes in system. The changes can be the modifications, removal of faults or major changes in features according to changing environments.

TQM defines changeability as, “it is a capability of any software system to enable a specified modification to be implemented”[73].

Changeability refers to how easily one can implement some modifications in the system where it requires. But at the time of changes, some care is always require like –

1. What are the other factors or properties of the system that will change?
2. How easy or difficult the change is to find?
3. Whether the change will satisfy the specifications or modifications?
4. Whether the change at level create problem to other level of the system?

Changeability can be distributed in three major categories [60]:

1) dynamic nature of the market,
2) evolution in technologies, and
3) Differences in environments.

TQM suggests a model for changeability. The Change Process model helps to find variability in changing environment and then the initiatives of it. The change process model is based on four important elements and eight change initiatives shown in the diagram [74].
This model gives a step by step approach to implement the changeability in organizations.

3.2.5.3 Stability

Stability refers to an ability of software or product to remain stable in the system.
Stability is an indication of response to system in harsh environment.

By definition, maintenance changes to the software will change its behaviour. When stable code is asked, one want code that minimizes the unexpected effects that occur as a consequence of the modifications we undertake. Two related attributes are fragility, the tendency of the code to crumble and break even after minute changes, and viscosity, the code structure that hinders changes that violate its design.

There are two major concepts to maintain stability as -

1) **Latency**: Time taken by the system to give response to an event
2) **Throughput**: Number events processed by the system in a given amount of time.
3.2.5.4 Testability

Testability refers to an ability of software or product to validate the results and covers all types of tests. Testability cross verify the specific criteria or standard defined. It helps to remove fault or damage.

Many testability Guru has done significant work on it and they specified the issues like [63] –

1. Complex applications
2. Lack of proper planning
3. Poor coverage of test aspect
4. Poor or wrong inputs and outputs

The diagram shows the level of testing [75].

![Figure 20: Quality Model](image-url)
Some of the important terms are:

1. **Testability**: The degree to which the software model facilitates test tasks in a given test context.

2. **Syntactic Quality**: Syntactic quality is the correspondence between the software model and its language definition.

3. **Semantic Quality**: Semantic quality is the correspondence between the software model and the domain.

4. **Well-formedness**: A software model is well-formed according to its language definition, if the software model complies to the constraints.

5. **Semantic Validity**: Validity means that all statements made in the software model are correct and relevant to the domain.

6. **Semantic Completeness**: A software model is complete when it represents all relevant features of the domain.

7. **Understandability**: The capability of the software model to be understood.

8. **Complexity**: The degree of difficulty in predicting the behaviour and cooperation of the system defined by the software model.

9. **Expressiveness**: A software model is expressive when it can be easily understood through the meaning of UML model constructs, without the need for further explanation.
3.2.6 Portability

Portability is an ability of software or product about how well it can be ported from one environment to other.

Portability in high-level computer programming is the usability of the same software in different environments. The pre-requisite for portability is the generalized abstraction between the application logic and system interfaces. Portability is the key issue for development of cost reduction, especially when software with the same functionality is produced for several computing platforms.

Software portability may involve:
- Degree of hardware independence
- Implementation language
- Comfort to specialized systems
- Hardware properties
- Structuredness: collect interchangeable program components.

Modern applications that push a technology’s state of the art rarely fit the requirements of a standardized environment and often need to address a number of portability concerns. The same is true for applications targeting real-world platforms rather than idealized execution environments. Thus, real-life code often has to address one or more of several dimensions of portability.

The Portability has following sub-characteristics :

6.1 Adaptability
6.2 Installability
6.3 Co-existance
6.4 Replaceability
3.2.6.1 Adaptability

Adaptability refers to an ability of software of product about how well it adopts the changes in the environment. Adaptability is the involvement capacity to which the web site attracts to users individually [27].

Adaptability is the ability of a process to accommodate change. Adaptability is not change control - it is the ability of a process to know when external conditions have changed and to dynamically reconfigure itself to handle those changes without sacrificing effectiveness or efficiency [74].

The Quality Adaptation Model (QAM):

TQM propose a reference the quality adaptation model (QAM) framework which helps to adaption needs of an organization [76].

![Figure 21: The Quality Adaptation Model](image)
The phases of QAM are:

1. **Context setting: Providing the basis for quality development**

   This provides base to quality development process. It ensures quality development in all parts of organization. It helps to form mission, vision, policy statements, short-term and long-term objectives of the organization.

2. **Model adaptation: Individualizing**

   This step finds the actors in quality development process. It studies the potential of all departments, employees and other working staffs.

   Then it finds their relevance to organizational benefits. When it is found, then it sets the objectives based on potential.

3. **Model Implementation and Adoption : Marketing the Concepts Work**

   Initially, adaption process involves small groups to form development strategies. Then the group takes actions to achieve quality.

4. **Quality Development : Improving the Organization’s Performance**

   Quality is an ongoing process which should be continuously evaluated by the organization. The continuous process improvement in the quality of the system leads to overall performance and success.
3.2.6.2 Installability

Installability refers to an ability of software or product about how well it install to systems maintaining compatibility without affecting the working of sub-systems. It also includes the amount of efforts require to install one software.

Installability is also specify as a term to efforts and time required by trained professional to install a software or any trained hardware engineer to perform complete installation of a system which includes other sub-systems like network.

Installability check is very important criteria for every product or software for the deployment of all activities. After purchasing a product, if it is not friendly with the other systems can create problem to access the data and form the correct results.

Installability is important when:

1. Software applications can be packed by non-professionals
2. Applications which require high availability of other systems to fetch or collect the data to complete some tasks.

Objectives

- The components should install easily
- At the time of installation process, money should be saved
- Increase the confidence in engineers to install the applications
- Reduce defects in installation process
3.2.6.3 Co-existence

Co-existence refers to an ability of software or product to remain available in the system in any harsh environment. It is also the measure of dependencies, concurrency behavior, or side effects of software or product in system.

Coexistence sub-characteristic measures the user’s capability to use the software being evaluated with other independent software. It can also measure the ease with which the software running on a given system. If any coexistence problems are indicated to the user at run time, it represents a form of documentation.

The key issues which can solve by Co-existence are:

1. Applications cannot handle increasing load
2. Users incur delays in response and longer completion times.
3. The system cannot queue excess work and process it during periods of reduced load.

Co-existence is a property which differentiates the software or a product with the other one. If the user faces problems with handling of applications, then user stops to use it. Here, the problem is not with the quality of the application, but the availability of an application in the system to give full benefit to the customers.

Co-existence is also applicable to the access load handle by the system. If the load handling capacity of the system is one lakh, and two lakh users are requesting for the access, then co-existence shows the stress capability of the system to give services without hanging overall system or down the server.
3.2.6.4 Replaceability

Replaceability refers to an ability of software or product about how well anybody, any time can replace one software or a part of it without affecting system processes. Replaceability describes the ability of software systems to function correctly with different alternative software components.

Modern software architectures frequently incorporate elements that are designed to be replaced at a later date. There can be the possibility that new versions of the software will come in the market or perhaps complete systems with which the application interacts will need to be exchanged.

Even if the replacement of software components is not planned at the moment, software stakeholders (especially business owners and operators) may demand the option to be flexible if new opportunities arise over the life cycle of the application. Now the need has arrived to find better software components that can be easily replaced and accept adaptability of existing system.

This sub characteristic aims at measuring the ease with which a user can use the software under evaluation instead of other (or vice versa)[2]. For example, if a word processor helps in migrating from another word processor by proving an option to keep the key mapping, it becomes a way of documenting the functionalities in a language familiar to the user. Replaceability can thus be an indirect measure of the quality of the documentation. Good replaceability helps keep our systems flexible.