

Six Sigma Approach to Quality and Productivity Improvement in an Institution for Higher Education

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Abstract—

Quality has become a competitive weapon in both the manufacturing and the service sector. And from past few decades, service sector particularly education sector has been neglected in terms of quality improvement efforts or we can say that quality improvement strategies are not being implemented in the education sector. Day by day the number of educational institutes is increasing and most of them are being managed by private management. As profitability is their major concern, therefore the aspect of quality is being overlooked. Today the higher educational Institutions are exposed with global competition and facing a lot of problems such as low graduation rates, higher drop-out rate, less employability etc. Therefore educational organizations must adapt six sigma methodologies to improve the quality of higher education. Although the method of applying statistical process control in education industry is really challenging but in this thesis we take a primary step to search out a solution for the education sector so that they can improve the quality of higher education.

Keywords— Six Sigma, Quality, higher educational institutes, service sector, DMAIC Approach, Internal Process Oriented System (IPOS) and Excellence of Performance System (EPS).

I. INTRODUCTION

Increased competition has motivated many senior managers in manufacturing organizations to evaluate their competitive strategies and manufacturing practices with the aim of improving organizational performance. Survival in a competitive environment has always been a challenge in the industrial scenario. In these days of globalization, liberalization and digitalization organizations find it difficult to survive unless they have competitive advantage.

The empirical evidence suggests that, give services of high quality will surpass the competition benefits and market penetration rate. Quality Management has gained in popularity mainly because of increasing customer consciousness of quality and growing international competitive pressure with the increasing need to cater to the growing demands of the customers and to cope with intensifying competition. Quality orientation seems to be the appropriate strategy to remain competitive. The single most critical factor needed for the survival and growth of an organization is quality. This has become far more important in expanding global market place facing major challenges through competition among players within and through increased customer's expectations. Companies providing quality products and services have gained competitive edge and greater market share. Many management personnel think that "Six Sigma" technique is applicable only to manufacturing industry and cannot be adapted to other areas, which is totally wrong. Wherever there are processes with a definitive output, six sigma can be adopted to improve the process to meet the customer requirement consistently. This can be restaurant, bank, hospital, airlines, railways etc.

Service sector is the fastest growing sector of the Indian economy. Service sector is not only dominant sector in India's GDP but also attracted significant foreign investment flows. And among the service industries; education sector is emerging as a major commercial activity in the nation. Globalization, growing competition among institutions, emergence of new technologies, changing socio-economic culture of nation and knowledge driven economies have created a scenario where quality in education has become a survival. Now the quality in educational organization is no more a desirable strategy – it has become a survival strategy.

II. LITERATURE REVIEW

Quality is a key component in achieving competitive advantage. The effective management of quality is the key to increased quality and enhanced competitive position in the current global environment. While firms such as Ritz-Carlton Hotel Company and Solctro Corporations enjoy their prosperity mainly due to their commitment towards Total Quality Management (TQM), some other firms like GE Capital, GE Fanuc, American Express, IBM, Citibank, and Motorola have been finding their own ways to prosperity through the Six Sigma way (Kuei and Madu 2003). Over the past few years, two approaches to process have gained wide spread acceptance. Six Sigma approach broadly applied across major corporations such as Motorola and General Electric, while others such as Lockheed Martin and Telecordia have focused on the Capability Maturity Model (Card 2000).

Customer satisfaction is generally accepted as the basic principle underlying most of the discussions related to quality. The importance of customer satisfaction achieved through product and service quality has acknowledged as a major factor contributing to competitive advantage (Issac et. al. 2006; O'Brien 1991).

(Prabhakar Kaushik, 2010) Six Sigma provides a philosophy to meet the diverse needs of industry with improved customer satisfaction and similarly, in academics, an institute can also be experimented with Six Sigma strategy to improve productivity. The project results reveal a need for better faculty, good infrastructure, more financial aid, better student faculty relationship and well planned curricula. The study could be a paradigm initiative for bringing in improvement on different aspects in existing education system. Technical education institutes should strategically plan to implement Six Sigma for continuous improvement and to achieve more customer satisfaction.

(Prof. Md. Rezaul Karim Ph.D,2012) Defining a common understanding of quality of higher education and establishing an improved knowledge and understanding of pedagogy can play a critical role in the higher education quality improvement initiatives.

Manuela Brusoni(2014) The paper reflects the progress made in describing, evaluating and defining the concept of excellence in higher education. It focus on the approaches to assess the quality of higher education. Excellence is something that is confined to relatively few institutions and subjects.

As an alternative, the six sigma is a concept that can be applied to all types of institutions and subject disciplines. It defines a goal to be achieved and can be recognized in terms of the value and worth of institutional practice. A criterion-referenced model defines excellence in relation to defined standards that in principle can be attained by all institutions.

Dr. R.M.Belokar(2015) Quality in education became an important fact due to increasing competitive environment. The quality in education is more important for the educational institution and the organization. In India there is a need of clarity in education as well as common understanding of education. The paper is focusing on the study of educational system with the use of operational tools and techniques which are used to get excellence in an educational system.

III. SIX –SIGMA METHODOLOGY

Six Sigma was first expressed by Motorola's in the mid-1980s. A Six Sigma initiative is designed to change the culture in an organization by the way of break through improvement in all aspects of the business (Yang 2004). Six Sigma is a business strategy that seeks to identify and eliminate causes of errors or defects or failures in business processes by focusing on outputs that are critical to customers. It is also known as measure of quality that strives for near elimination of defects using statistical methods .Six sigma has been proven to be a powerful enabler for process improvement. Six sigma provides the comprehensive tool for understanding customer requirement, understand the data and define and improve processes. Six sigma quality improvement techniques can be successfully applied in the service sector and of course in education sector also.

IV. DMAIC METHODOLOGY

Define

All along organization have been carrying out process improvements in a number of ways with no clear process/goal However six sigma process improvement has a clear and well laid-out methodology for getting the right solutions. The methodology makes it possible to identify the problems, collect necessary data regarding the problems, identify the possible causes and find solutions.

Six sigma projects must translate the often vague and ambiguous needs of customer into clearly defined measurable attributes with an acceptable or not acceptable level of performance called a specification. The problem needs to be defined in concrete measurable terms with an operational definition. The six-sigma is a clear and well laid-out methodology for getting the right solutions at the right time. The methodology helps to identify the problem in a product or process, collect necessary data pertaining to the problem, identify the root causes and find proper solutions. Many organizations are greatly benefited by applying or implementing this methodology and therefore this process has been proved as an effective management tool. Six Sigma quality standards are achieved by following the DMAIC process. This improvement methodology has been successfully used globally to improve the product or process performance both in manufacturing and service sector.

During this phase, the institution's purpose, goal or scope is well defined. To identify problems, a team is formed, key customers are identified and required outputs are gathered to prioritize student's requirements and the current process is documented. In this phase the critical success factors are examined or studied to produce innovative and skillful graduates.

The following are to be defined as the first step of six sigma improvement process:

- Define key customer.
- Define key customer requirement that is Voice Of the Customer(VOC)
- Define the problem.
- Define the core process.
- Define scope/goal
- Define the projects.
- Define phase deliverables.

Defining Key Customer:

In an educational organization, customer is a student who takes admission in graduate or undergraduate courses. Every student want good passing rate and placement opportunity after the completion of his/her course.

Preparing Problem Statement:

As a first step, it is mandatory to understand the current problems in the organization that are occurring in meeting the customer requirement. Creating a good problem statement, also known as project statement, could take a lot of thought and work. The problem statement must be specific in defining the problem and quantify the effect of the problem. The problem statement is prepared on the basis of the problem in the organization.

Based on the problem in the educational organization, a problem statement is prepared and detail is included in a problem statement:

Problem Statement	Customer affected
Project Name: Six Sigma Approach to Quality and Productivity Improvement in an Institution for Higher Education	Current students that are perusing graduation and after graduation course in the organization.
What is the problem?	Quality in an educational institute is becoming an issue that relates to the quality of teaching, the capabilities of students, the scale of resource provisions, placement process and the pass percentage secured by the student.
How do I identify the problem?	Low passing rate of students, Less placement opportunity, higher drop-out rate fails to meet students expectation
What is the effect of the problem?	Effect on student, parents, educational organization, placement agencies and industries and on the reputation of the organization
When does the problem occur?	Generally During semester
If no action is taken, What is the effect of the problem?	Dissatisfaction among parents and students, reputation of the organization will diminish.

Fig.1 Problem Statement

Project Charter is a basic document prepared before starting any six sigma project that clearly states the problem, the goal and the time frame to achieve the goal with clear business results. This is also used by the project team to get a clear direction as to what is expected by the team.

Stakeholder analysis:

The stakeholders are the person who might affect or be affected by the project. Stakeholder analysis is important to identify the people, groups and organizations that will influence the project either positively or negatively. The stakeholders involved to improve the quality in educational organization are as following:

Students, parents, other Educational organizations or universities, alumni of the organization, industries, employers, principal, dean, professors, associate Professors, assistant Professors, instructors, technicians, administrative and Supporting Staff

SIPOC Model:

SIPOC is nothing but a high level process map. A high level process map gives a bird's eye view of the project. This is not a detailed process map but gives a fair idea of the total process. SIPOC consists of the following elements:

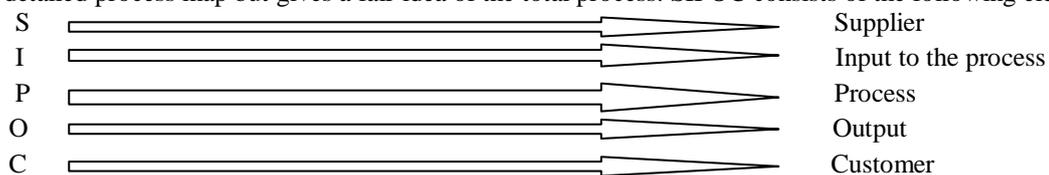


Fig. 2 what is SIPOC Chart

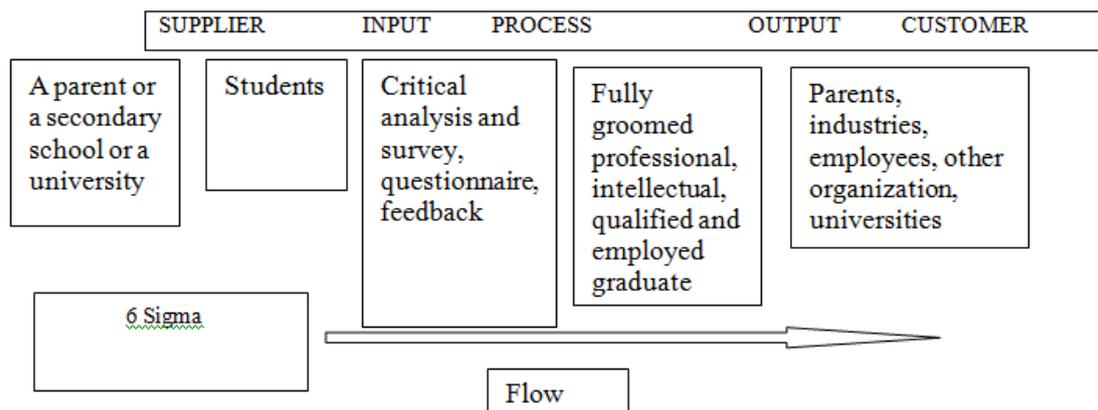


Fig. 3 High Level Process Mapping

V. MEASURE

Every organization measures the performance parameters during the course of the day to access whether the plan are working and achieving the desired results. If there were no measurements then it will not be possible to know whether the organization is meeting the customer requirement and making profits. At the same time it is not economical to measure every activity and control all the parameters. When there is a specific problem in the organization to be eliminated, the first step is to measure the extent of the problem.

Measure phase helps in measuring various performance parameters during the project execution to examine whether the plans are working in right direction. Key performance parameters are measured to find the solutions and eliminate the problem in any process. During this phase, the performance of the current process is measures to identify the problem and finally finding remedial solution to eliminate it.

During the measure phase, all measurements are undertaken related to the problem area and before proceeding with the measure phase, it is necessary to understand the following :

- What needs to be measures?
- How to measure it?
- What is the customer requirement?
- What is the variation between the customer requirement and current level of performance?
- Is their any additional measurement required to precisely know the problem?
- What measurement is required after the process is improved?

CTQ Tree

Identification of CTQ will help in determining the factors that contributed to student attrition. In order to clearly identify the exact problem of the customer and to understand the problem better, a CTQ tree is to be prepared by the following process:

1. Identify what is with the critical-to-quality requirement of the customer.
2. Specific output required to be measured.
3. Identify features/dimension of that output which is “critical to quality”
4. Brainstorm specific kind of data associated with the critical-to-quality characteristic and arrange them logically
5. Identify critical parameters of the output to be measured.
6. Confirm data to be collected

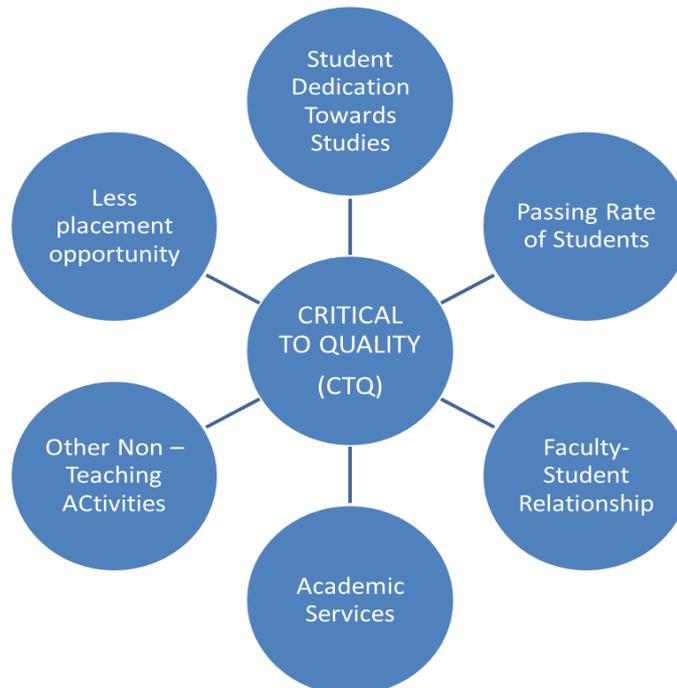


Fig. 4 Critical To Quality

FMEA:

Failure mode effects analysis (FMEA) is a bottom up and analytical tool that we can use in Six Sigma to quantify and prioritize risk within a system and then track actions to reduce that risk.

Problem of Low Passing Rate:

To study the problem of low passing rate of students, data is gathered for such duration that all possible variations in passing rate are covered. For calculating sigma level, last ten years pass percentage of students is gathered from ERP (Enterprise resource Planning) System of the organization.

Both quantitative and qualitative control charts have been developed to monitor the students and the institution. The two quantitative Charts are the Individual/Moving Range chart (IX/mR) and the Average/Range Chart. To monitor every

student performance, IX/mR chart was developed using the following steps:

1. Last 10 years passing rate data is gathered.
2. Moving Ranges are calculated (difference between each successive point)
3. Data is plotted in time-series order.
4. Plotting the moving ranges in some order series on the moving Range(mR) chart

Table I Courses And CGPA In A Subject With Moving Range (MR)

Subject Name	CGPA Received	mR
BMCI 101	8	
BMCI 102	6.6	1.4
HVPE 101	7.4	0.8
BMCI 103	6.6	0.8
BMCI 104	8	1.4
BMCI 105	6	2.0
BMCI106	6	0
BMCI 201	4.2	1.8
BMCI 202	6.6	2.6
BMCI 203	7.4	0.8
BMCI 204	5.4	2.0
BMCI 205	5.4	0
EVSC 201	5	1.4
BMCI 206	2.6	1.4
BMCI301	5.4	2.8
BSBC 302	6.6	1.2
BSBC 602	7.4	0.8
BMCI 302	6	1.4
BSBC 603	7.4	1.4

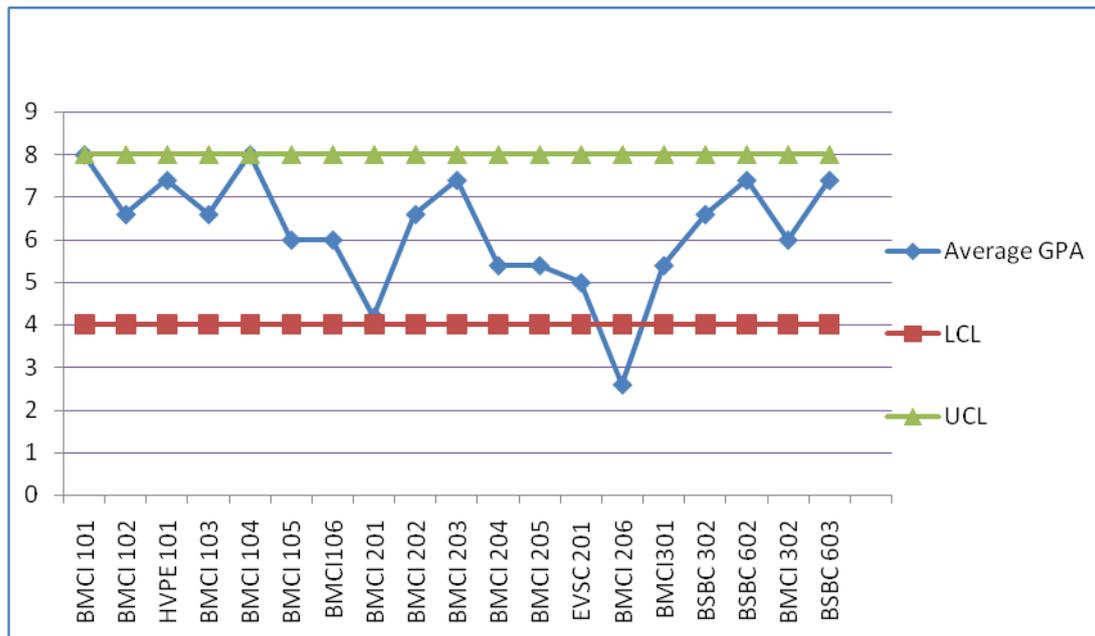


Fig. 5 Average CGPA of a student in a particular subject of a course

Table II UCL and LCL of Individual Control Chart

Average CGPA	UCL(IX)	LCL(IX)
6.2105263	8	4

The current study for an individual student was based on CGPA in every course. The Upper Control limit of 8.0 represents the maximum attainable CGPA and lower control limit of 4.0 represents the minimum required CGPA by the university to be in good standing. Student with less than 4.0 CGPA has to re-appear in a particular exam.

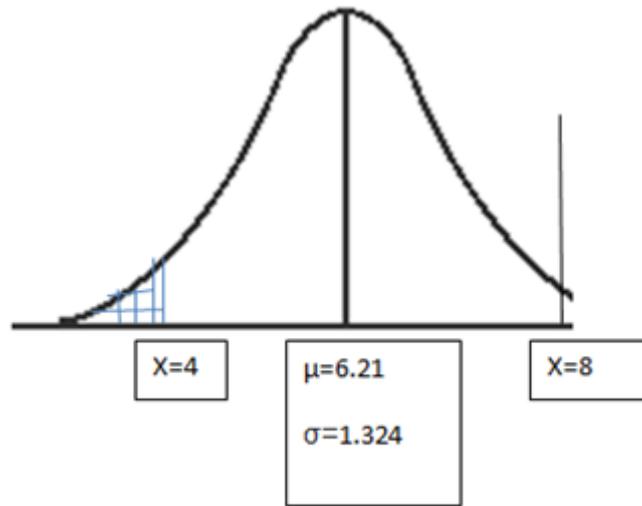


Fig.6 Shows the normal distribution curve for the student's grade

It is observed from a control chart that a process is not control for one course with code, BMCI-206 as it is lower than the lower control limit. This clearly identified improvement is required in a particular subject area.

The area to the left of $X=2$ is calculated as: **0.0475**. It means approximately 4.7% of the students secured CGPA of less than 4. Defect per million opportunity is 47500 that is close to 1.55 sigma level or nearly **2 sigma level**. Therefore to increase sigma level, quality improvement techniques must be adopted in the organization

VI. ANALYZE

Analyze phase of the six sigma improvement process works on the premise that the output of the process depends entirely upon the input variable and the conversion process to get the desired output. During analyze phase, the team has to analyze all the causes of the problem and finalize a list of causes to be eliminated to achieve six sigma performance.

Through analysis, the team can determine the causes of the problem that needs improvement and how to eliminate the gap between existing performance and the desired level of performance.

Fish-Bone Diagram

The brainstorming points (Critical Systems) with their key critical factors (KCF's) in the fish bone diagram as following:

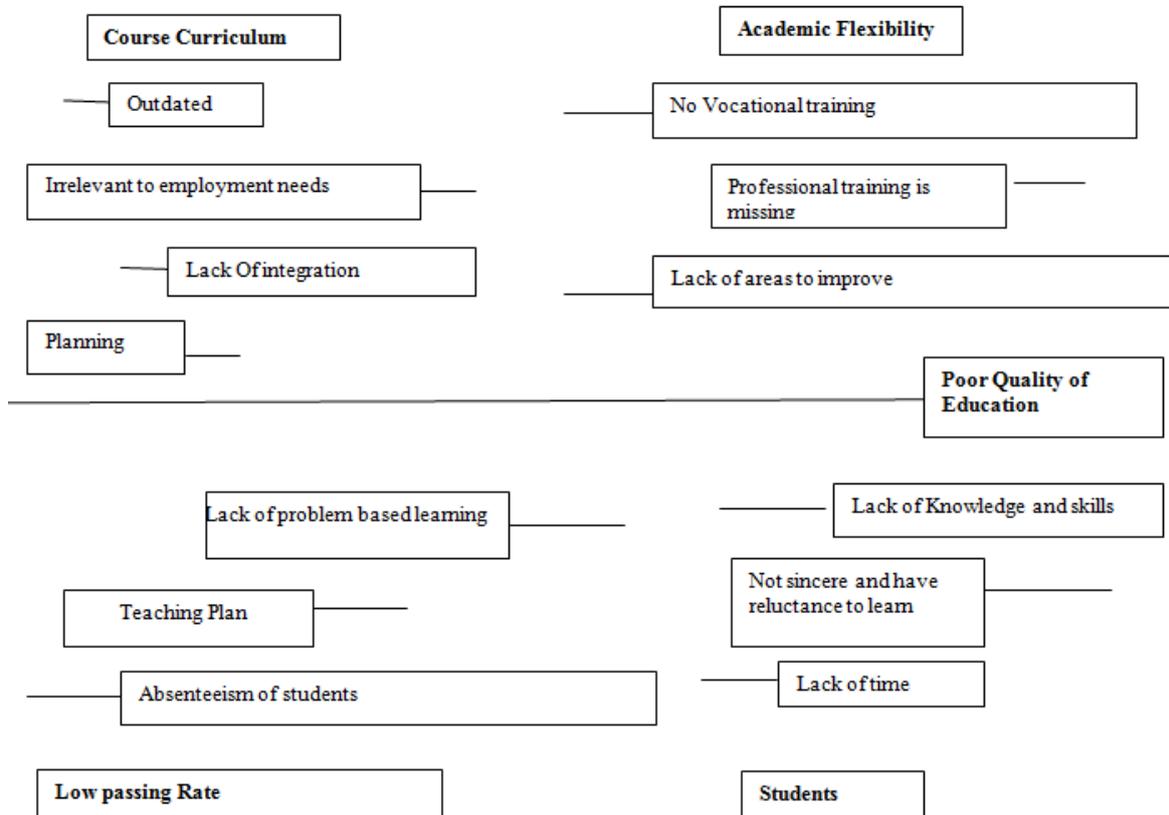


Fig. 7 Fish bone diagram of quality of higher education.

VII. IMPROVEMENT

This phase is often the most important phase of the six sigma improvement effort. . Once problem causes are determined in the Analyse phase, the team finds creative new improvement solutions.

Therefore

- Separate discussion rooms are made to explore modes and to reinvent the education or course curriculum.
- The process of teaching and learning should focus on the satisfactory planning of elements such as course content, strategies adopted, curriculum, assessment and other parameters.
- Good practices are adopted to minimize the pass percentage of students.
- Feedback from academic peers, alumni and employers is used in the initiation, review and redesign and reinvent the curriculum.
- The institution now has a well-conceived plan to monitor student progress continuously.
- The reliable, accurate , valid and online student assessment procedures must be implemented to track each student's performance and it helps to optimize their performance.

For the effective curriculum delivery and transaction on the curriculum provided by the University, the college adopts a comprehensive strategy to implement it effectively through its “**Internal Process Oriented System**” (IPOS) and “**Excellence of Performance System**” (EPS). These help in adopting the processes in a very logical and effective manner.

- To ensure 100 % placement, all the students are required to undergo on the job training during their last semester as a part of curriculum. The placement cells of the college oversee it. This helps them to give the industrial exposure before they are placed. A student may be given stipend during the on job training.
- Integrated Educational Quality Management system (IEQMS) must be implemented to achieve global quality standard in every educational organization

VIII. CONTROL

Success in this phase depends upon how well the things are done in the previous four phases. If proper change management methods starting with identifying key stakeholders are used, one should be on the way to success. In the Control phase, tools are put in place to ensure that the key variables remain within the acceptable ranges over time so that process improvement gains are maintained. The team develops a project hand off process, reaction plans, and training materials to guarantee performance and long-term project savings. Finally, the team identifies what the next steps are for future Six Sigma process improvement opportunities. The last step is synergizing which is to ensure the gains a Six Sigma team has made are shared with the organization as a whole. This sharing is needed to help create a learning organization.

- A formal Internal Quality Assurance Cell (IQAC) has been set up in the Institute to ensure Quality within the organization
- the feedback of the students and other stakeholders is taken regularly on teaching, learning, and curriculum design to assess the performance of teachers vis a vis the curriculum taught by them.

IX. SUMMARY

Quality in the education has been proven to have positive effects ensuring equality of opportunity in education, reducing learning time and education costs ,enhancing teaching-learning process thus increasing the number of individual experts or Professionals, providing social awareness to society and nation.

Six Sigma quality improvement methods can easily be applied in HEI The objectives of this research is towards introducing Six Sigma as a way to improve the quality of Higher Education Institutes.

X. CONCLUSION

I applied DMAIC approach to find out the various root causes that influence the low pass percentage. The organization showed a three sigma (3sigma) level quality which means significant improvement is required to achieve 6 sigma level. The main results or outcome of research is lessons which I have learned from literature reviews, research paper and case studies is that Six Sigma methodology can be used as a guideline for educational organizations to implement for quality improvement methods and to satisfy the customers. And researchers can also use this method for the further research in the field of quality& six sigma.

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