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Transforming Quality of Higher Education Institutions in India: Based on a Case study using DMAIC

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ABSTRACT

Higher education is a significant factor in determining the overall development of a nation, which takes into account not only its economic, social, and industrial aspects but also a great number of other considerations. Higher educational institutions in India, such as colleges and universities, have the responsibility, in the present day and age, to equip young people with the skills they need to be self-sufficient by offering education of the highest possible standard in the fields of education and research. In this article, we hope to demonstrate how the methods of six sigma (DMAIC) can be applied to enhance quality in college and university operations, with the end goal of increasing the value of the degrees that are offered. In this paper, an in-depth discussion is given on a case study that was based on the cumulative grade point average (CGPA) of the students who attended a private engineering college that was then affiliated with Assam Science and Technology University.

Keywords: DMAIC, Higher Educational Institutes, Six Sigma, Quality, Control Chart

INTRODUCTION

India's higher education system is the most diverse in the world, making it the largest overall, placing it third among the world's largest higher education systems behind China and the United States of America. Since India's independence, the country's higher education sector has undergone tremendous expansion, as evidenced by the opening of a large number of new universities and colleges [1]. For a long time, institutes of higher education (IHEs) in India have been facing enormous challenges on several fronts. These challenges include low graduation rates, rising apprehension on the relevance of the awarded degree for any good public use, a lack of region disparity due to the fact that the majority of premier higher education institutes are located in metropolitan and urban cities, and so on. There have been recent calls to improve these processes in educational institutions of higher learning (HEIs), in response to the growing importance of quality excellence in both the traditional classroom style of education and other components of HEIs. Higher education quality is determined by a number of factors, including the curricula and topics covered in courses, the students who enrol them the instructors, and the teaching and grading strategies that are utilized.

The overall scenario of higher education in India does not match up with the quality standards that are prevalent worldwide. As a result, there is sufficient basis for an increased assessment of the quality of the educational institutions located throughout the country. This approach to determining quality in higher education, which is more commonly known as the "value addition" method, does not measure the competencies that students develop through the courses that are provided. The coherence of the curriculum can be increased with proper quality management, education can be improved, the productivity of the teachers can be enhanced, and both teachers and students can experience a greater sense of joy in their work and be in a position to make positive contributions to society.

LITERATURE REVIEW

Sylvie Nadeau et al. (2017) acknowledge that dynamic changes in economic, demographic, social, technological, and political conditions place tremendous pressure on academic institutions. In response, universities are implementing new management strategies such as lean, six sigma, and lean six sigma. While the few available measured results suggest that they do hold promise, their impact is still unknown [2].

Cudney et al. (2018) examine the systematic role that lean and six sigma play in the constant improvement in higher education. The findings indicated that these approaches can be utilized to enhance teaching strategies, administrative procedures, and other aspects of higher education institutions [3].

Seamus J. O'Reilly et al. (2019) intends to contribute to the growing body of literature on continuous improvement achieved by lean six sigma in higher education institutions. Several specific enhancements were accomplished, including a reduction in cycle time and costs, customer or employee satisfaction, and rework and error reduction [4].

Marco Maciel-Monteon et al. (2020) propose the design and validation of an instrument to evaluate the implementation of six sigma critical success factors in higher education institution improvement projects. The results demonstrate the statistical validity of the proposed instrument, allowing higher education institutions to use it to evaluate how Six Sigma critical success factors are handled during the development of improvement projects [5].

Ameen Abdullah et al. (2022) identify and eliminate the various flaws associated with technical education using a variety of quality tools. According to the findings, the critical success factors for the proposed six sigma model were the adaptability of programme curriculum, the credibility of universities, and laboratories and workshops [6].

Based on the above stated literature review, which has been done periodically, it can be claim that lean six sigma process is an effective process in identifying the critical problems that are existing in the higher educational institutions and helps in resolving this problems to enhance the efficiency of the HEIs.

METHODOLOGY

The DMAIC model serves as a road map for the Six Sigma methodology, which aims to enhance the quality of the results produced by business processes. The steps of "Define," "Measure," "Analyze," "Improve," and "Control" can be shortened to "DMAIC." In order to complete this process, you will need to follow a total of twelve steps, which are broken down into five distinct sections [7].

The DMAIC model consists of twelve steps, as was previously stated. In this section, we delve into the specifics of each of the 5 phases and the 12 steps listed below.

Define Phase
Deals about problems that need to be solved and their importance to the company should be discussed. Set up a work group to address the issue of quality improvement.

The Define phase consists of the following two parts:

- The process of selecting and defining a project
- Defects are defined here.

Measure Phase
To identify the problem and gather preliminary information on the product or process's effectiveness. Identify areas for improvement and put a plan in place to track progress.
The following steps are taken during the Measure phase:

- Determine and investigate measurement system
- Baseline performance
- Goal setting based on previous performance

Analyze Phase
Determine which process inputs or parameters have the greatest impact on the most important process outcomes or outcomes of concern (outputs).
Analyze is broken into two distinct phases:

- Variation's root causes
- The identification of main factors.

Improve Phase
In order to identify areas for improvement backed up by evidence that these improvements will help the project meet its objectives.
This phase is comprised of the subsequent actions:

- Identifying the most efficient and effective system
- Putting the proposed solution to the test

Control Phase
To implement the chosen solutions and ensure that these are incorporated into the organization's workflow. Share the solutions with other stakeholders who are dealing with the same problems.
The following are the steps that make up this phase:

- Developing and analysing data collection methods
- Documentation and handover of the project
- Implementation and proof of the improvement.

The DMAIC model is typically and frequently connected to the Six Sigma methodology. This is due to the fact that it was derived from the said method and is, in fact, employed directly as the working model for Six Sigma. However, this does not imply that the DMAIC model is incapable of functioning without the Six Sigma methodology.

OBJECTIVES

It was decided, after going through some of the critical research articles published regarding the quality improvement in higher education system in India, to outline the fundamental goals of this work. This decision was arrived at after conducting a review of the relevant literature. The following is a list of them:

- The objective of this work is to study the various evaluation schemes and matrixes of premier Indian and foreign higher educational institutions.
- To understand the relation between academic performance of the student and his/her quality of placement.
- To understand the requirement of corporate from graduates of higher education institutions (secondary data and reports).
- To provide step by step solution to improve quality of academic performance of a student in order to boost reputation of institution this will enhance the placement scenario.
- To implement DMAIC methodology with regard to a case study based on the CGPA of some randomly picked up students from a private engineering college.

RESULTS AND DISCUSSION

Observations
The observation which will follow has been obtained by consulting and having casual yet important discussion with the faculty members, technical staff and non-teaching staff of Royal School of Engineering and Technology, then affiliated under Assam Science and Technology University (ASTU), Guwahati, Assam.

Study about various evaluation schemes and matrices of the concerned educational institute:

- The institution has a common done-to-death sort of evaluation pattern which is being carried out since last few decades. Some of them are listed below:

- **Evaluation through internal tests:** Internal assessment of the students is carried out as per the regulations and norms of the University

- **Evaluation through university exams:** The University examinations are conducted on as per the rules, regulations and guidelines issued by the affiliating University from time to time.

- **Evaluation through assignments:** The faculty in-charge of each subject will work out and announce the topics for assignments to be written by the students along with deadlines for submissions at the end of each chapter.

- **Evaluation through subject based viva voce:** Certain amount of internal marks is set a part to be granted based on the performance in the viva-voce.

Based on the above observations and suggestions provided by concerned shareholders, we would like to recommend certain amendments in the existing evaluation system:

- **Major revision of syllabus:** The syllabus of all the courses are revised from time to time so as to keep it updated to the present relevance.

- **Increased internal assessment:** In line with modern thinking on education, focus has been given to internal assessment by increasing the weightage of internal assessment marks.

- In the continuous evaluation based on objective-type questions, measuring the higher mental ability of students should be adopted.

- All the examination processes should be computerized and recent advances in ICT should be exploited to make the process automated and efficient.

Study to understand the relation between academic performance of the student and his/her quality of placement:
As we know campus placement enable the students to start their professional career right after they have completed their course curriculum. A proper strategy must be carried out by placement and training cell of the colleges in order to ensure placement of a correct candidate for appropriate job.

Still some of the challenges faced by most of the colleges with regard to campus placement are listed below:

- **Technological Transformation:** With many new and diversified jobs have come into existence, our course curriculum has become dated to cater the demand of these jobs.
- **Gap between skill sets and Industry requirement:** Considering the trends, education system now has to be developed in such a way that it prepares the students for jobs which are not even created as of now.

Based on the suggestions and recommendation given by various students as well as in-charges of T&P cells, certain potential steps which must be taken up are given as:

- **Skill training and employability:** As Companies no longer just look for academic excellence and aptitude but they prefer candidates who have practical exposure and hence industrial training should start from 1st year.
- **Placing right candidate for the right job:** Companies must critically focus on the "Attended vs. recruited" numbers when they visit a college for campus recruitment. It gives them a fair idea of which colleges have high quality or job-ready candidates.

Study to understand the demand of corporate companies from graduates of higher educational institution:
Based on the data and interaction with some working individuals in corporate companies we can point out certain demands of the companies while recruiting graduates:

- **Critical thinking:** Ability to obtain, interpret, and use knowledge, facts, and data in this process, and demonstrate originality and inventiveness.

- **Oral/Written Communication:** Articulate thoughts and ideas clearly and effectively in written and oral forms to persons inside and outside of the organization, public speaking skills etc.

- **Team work:** Ability to work within a team structure, and negotiate and manage conflict.

- **Leadership:** Ability to judge and manage one's emotions and those of others; use empathetic skills to guide and motivate

- **Intercultural fluency:** Value, respect, and learn from diverse cultures, races, ages, genders, sexual orientations, and religions, demonstrate openness

Still the companies' faces challenges while recruiting graduates and some of them are listed below:

- **Attracting right candidate:** It is very difficult to select the right candidate in a pool full of unqualified talent

- **Engaging qualified candidate:** Need to put extra effort into persuading passive candidates to choose your company over the rivals

- **Faster Hiring:** Hiring teams want to hire as fast as possible but depending on industry hiring gets delayed which eventually leads to having dearth of qualified candidates

- **Fair Recruiting:** Many companies struggle to attract and hire diverse candidates due to unconscious biasness and legal issues.

Based on viewpoints given by students and T&P cells of colleges, we would like to enlighten the corporate companies with some suggestion as given below:

- Be clear about the requirements in your job ads and give a concise view of the role.
- Before contacting a passive candidate, research properly about their needs and try to fulfill that

Sometimes it takes long time to hire as it is natural when you're hiring for hard-to-fill roles. Explain that to the hiring teams and set expectations early on.

Implementing DMAIC on CGPA of Students
Define Phase:

In most of the times, the potential suppliers to the higher educational institute i.e. private engineering college in this work are the high schools, junior college graduates, diploma colleges and some of the already passed out students from previous years. The customers are generally the recruiters, institutions, society etc. The process of converting these high school/junior college graduates/ Diploma college graduates to the engineering graduates takes place in basically 3 or 4 years of course curriculum. A process chart in this regard is shown below in the table 1.

In a diverse nation like India, the course curriculum and the evaluation process in engineering degree varies from college to college and hence to maintain uniformity in recruiting or higher study admission, a candidate with 75% and above is always considered to academically sound.

Table 1: Process chart for six sigma process in higher educational institute (private engineering college)

Suppliers	Input	Processes	Output	Customers
High Schools	High School Graduate	Fresher/ 1st Year	Engineering Graduates with Bachelor Degree	Recruiters
Junior Colleges	Junior College Graduate	2nd Year		Institutes
Diploma Colleges	Diploma College Graduate	3rd Year		Society
Technical skill development centres	Certified Technical Skilled candidate	4th Year		

Measure Phase:
There are many factors which define success in higher education as it can be pass percentage of the students, retention rate of the student, percentage of students recruited in a particular year, number of students intake increased in a particular college due to excellent performance of previous batches of student and many more. But this above stated does not provide base for individual potential judgement of a candidate. Thus the CGPA earned by each student provides a definite scope to judge their ability individually.

For creating quantitative and qualitative control charts, we at first would like to share the existing grading scale of Assam Science and Technology University, Guwahati, Assam in table 2 provided below.

Table 2: Marking Scheme applied to every student registered under ASTU, Assam.

Percentage Range	Grade	Description	Grade Points
90 & above	Ex	Excellent	10
80-89	A	Very Good	9
70-79	B	Good	8
60-69	C	Fair	7
50-59	D	Average	6
45-49	E	Below Average	5
35-44	P	Pass	4.5
Below 35	F	Failed	0

The semester grade points awarded (SGPA) in all the 8 semesters of the course is responsible for evaluation of the cumulative grade points awarded (CGPA) to an individual student. The formula used to evaluate the SGPA and CGPA by the concerned university ASTU, Assam is provided below.

SGPA = $\sum_1^n \boldsymbol{GPi} * \boldsymbol{NCi} / \sum_1^n \boldsymbol{NCi}$
Where, GPi = Grade point earned in the course
NCi = Number of Credits for the course
n = Number of courses in the semester

CGPA = $\sum_1^n \boldsymbol{SGPAi} * \boldsymbol{NSCi} / \sum_1^n \boldsymbol{NSCi}$
Where, SGPAi = SGPA of the i^{th} Semester
NSCi = Number of credits in i^{th} Semester
n = Number of semester completed

The conversion of CGPA into percentage formula adopted by the university since 3rd August 2017 is given as

Percentage = CGPA * 10

The CGPA of 20 candidates picked up in random manner from a batch of 120 students under Mechanical Engineering Department (2013-17), Royal School of Engineering and Technology, then affiliated under Assam Science and Technology University (ASTU), Guwahati, Assam. The roll number of the students and their CGPA are listed in the table 3 given below.

Table 3: Roll Numbers and CGPA of the students earned in 2013-17 Mechanical Engineering batch of Royal School of Engineering and Technology.

Serial No.	Roll Number of the Candidate	CGPA earned	Magnitude Value of Moving Range
1	1302102001	7.19	
2	1302102004	6.56	0.63
3	1302102011	7.48	0.92
4	1302102024	7.55	0.07
5	1302102027	7.49	0.06
6	1302102035	7.68	0.19
7	1302102041	6.42	1.26
8	1302102045	6.39	0.03
9	1302102054	7.6	1.21
10	1302102059	7.77	0.17
11	1302102080	7.76	0.01
12	1302102085	6.51	1.25
13	1302102091	9.05	2.54
14	1302102106	8.57	0.48
15	1302102110	6.36	2.21
16	1302102116	7.56	1.2
17	1302102118	6.73	0.83
18	1302102089	6.49	0.24
19	1302102111	6.82	0.33
20	1302102062	8.51	1.69

The first chart which has been obtained in this work is that of the individual control chart i.e. basically X-bar chart for the CGPA obtained by the 20 student who have been picked randomly. The table 4 provided below gives the information about the upper control limit (UCL) and the lower control limit (LCL) of the obtained individual control chart. In order to calculate the UCL and LCL for the individual control chart, the factor A_2 taken for 20 observations in a single sub-group as the students are from same batch and same department has been taken as 0.18.

Table 4: UCL, LCL and Standard deviation for Individual control chart

Individual Control	Chart data
Average CGPA	7.3245
Upper control limit (UCL)	7.469

Lower control limit	7.179
Standard deviation (σ)	0.790546

The individual control chart obtained for the CGPA data has been shown in figure 1 given below.

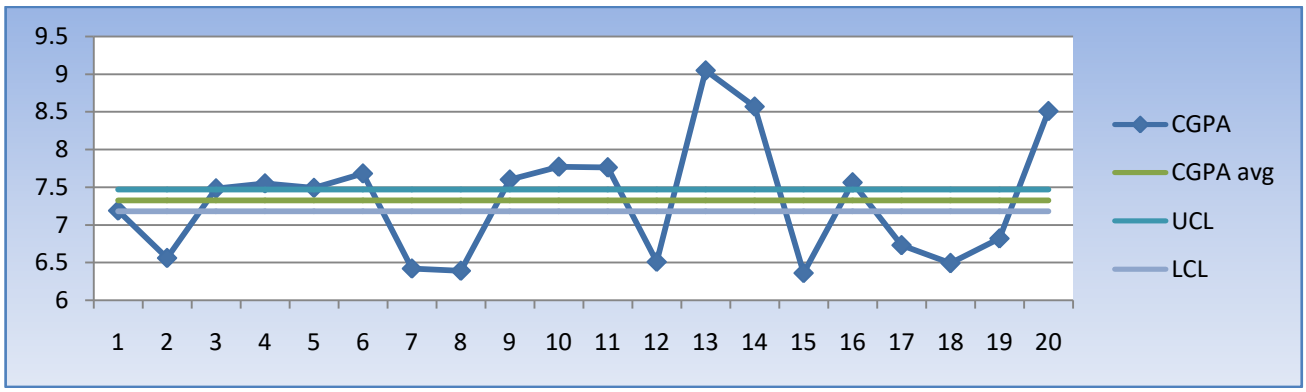

Fig 1: Individual Control Chart for CGPA

In order to prepare the moving range chart, the UCL and LCL of the chart needs to be calculated. The factors for R chart D_3 and D_4 has been taken as 0.41 and 1.59 respectively as all the 20 observations are from a single sub-group i.e. from the same department. The table 5 provided below gives the information about the various data obtained with respect to range chart.

Table 5: UCL, LCL and average Range values for the Moving Range chart

Moving Range	Chart data
Average mR	0.8063
UCL	1.282
LCL	0.3305

The moving range chart for the data obtained in table 1 is shown in the figure given below.

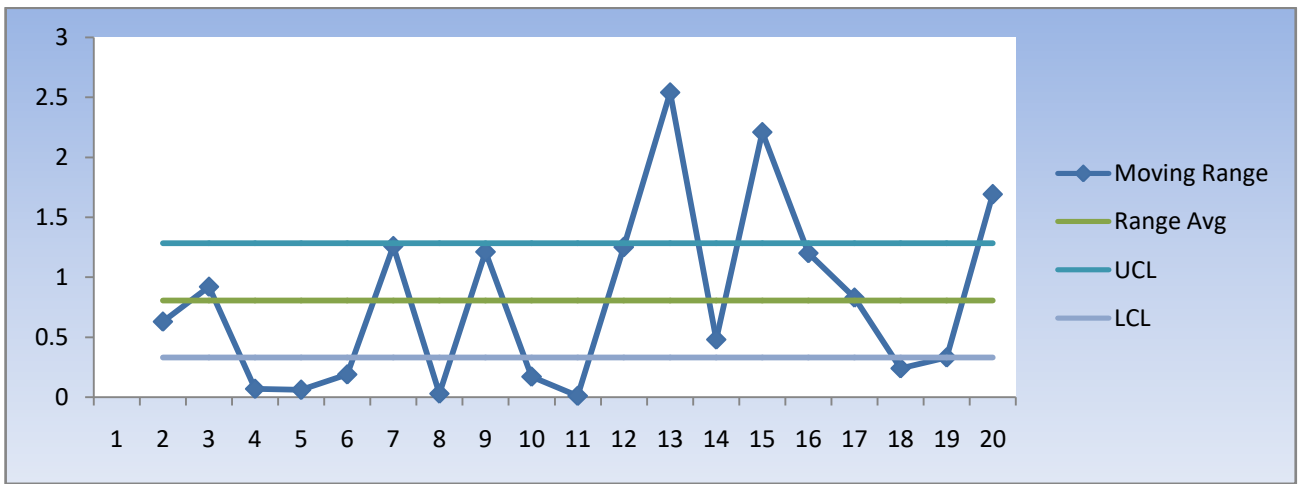

Fig 2: Moving Range Chart

Since we can observe that there certain points in both individual control chart and moving range chart are out of control limit. This means the data are not in stable condition and the existing system is faulty one.

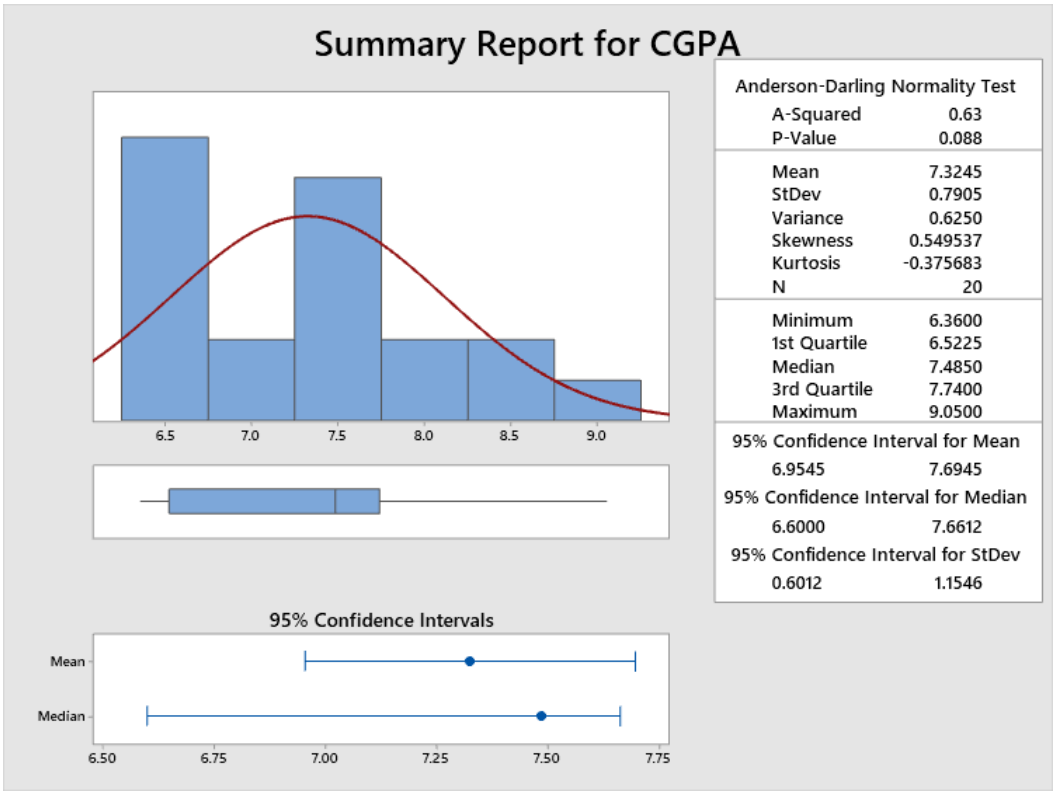

Fig 3: Normal Distribution Curve for the 20 CGPA values used in this work

The above figure is of the normal distribution curve obtained for our piece of work having a P-value of 0.088 which is greater than 0.05 at 95% confidence interval, thus we can affirm that it is a normal distribution curve with mean μ = 7.3245 and standard of deviation σ = 0.7905. As per our statement of problem that a candidate with 75 % and above is considered to be academically sound for higher studies as well as become eligible for recruitment in any diverse condition, hence as per the CGPA to percentage converter formula of the consulting university ASTU the minimum CGPA for achieving that should be minimum of 7.5 and CGPA which is less than 7.5 will be considered as failure as per our problem statement.

For evaluating probability in case of a normal distribution function can be given by the formula as stated below:

$$\mathbf{P(z) = (z - \mu)/ \sigma}$$

For failure of our intended problem statement, $z<7.5$

$$(z<7.5) = (7.5 – 7.3245)/ 0.7905$$
$$= 0.222$$

$$P(z < 7.5) = P(0.222)$$
$$= \mathbf{0.58784}$$

If we consider the whole batch of Mechanical engineering (2013-17), the total numbers of students were 120.
Number of students without having 75 % will be

$$= 120*0.58784$$
$$= 70.54$$
$$= 71 \text{ (approx.)}$$

The number 71 out of 120 students is quite high and in order to achieve six sigma level of quality this must be reduced with proper analysis.

Analyse Phase:
As observe in the measure phase, there is some problem associated in the system of our study. The main aim of analyse phase is to identify those causes and what implications they are having on the system. After having thorough conservation with the faculty members, students of the concerned department and all other share holders, it was decided to prepare the cause and effect diagram popularly known as Ishikawa diagram. The fish-bone diagram is shown below.

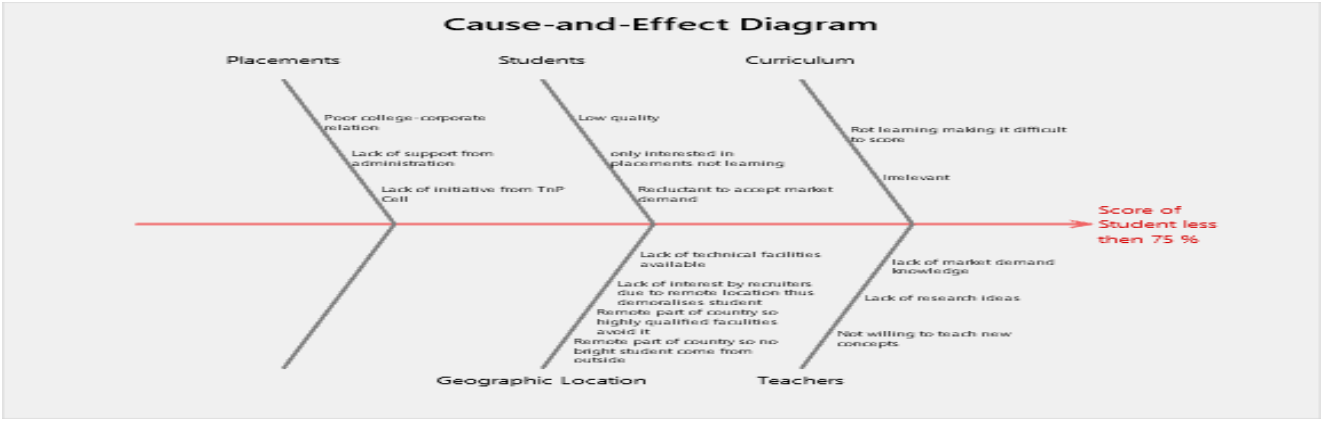

Fig 4: Cause and Effect diagram for the concerned problem

Improvement Phase:

A failure mode and effect analysis (FMEA) can be used to improve the process. A step-by-step procedure is used to identify all possible causes of failure and their corresponding effects with recommended corrective actions to avoid the failure modes. The FMEA is shown in the table given below.

Sources of Poor Quality	Failure Mode	Failure effects	Failure cause	Control action	Recommended action	Responsibility
Students	Reluctant to learn	Poor Graduate	Lack of interest	Self assessment	To know value of education	Himself/Herself
	Lack of knowledge/skills	Not matching industry requirement	Skills not transferred properly	Evaluation & guidance by teachers	Ensure proper transfer of skills	Teachers & Lab instructor
	Lack of time to study	CGPA <4.5 and failure	Bad time management	Personal assessment	Educate on proper time management	Teachers & Mentors
Curriculum	Outdated	Defunct Knowledge of student	No source of update	Updated curriculum	Proactive Syllabus approval committee	Technical Council
	Irrelevant to employment needs	Unemployable Graduates	Lack of interaction with industry	More industrial training	Proactive College T&P	Technical Council & College management
	Lack of continuity	Students cannot connect topics from one semester to another	No interest in curriculum	Practical and innovative curriculum	Proactive Syllabus approval committee	Technical Council
Teachers	Research Pressure	Shortage of time for classroom teaching	Concentrating on lot of research work	Number of research paper published	Limit the number of research work based on semester	Teacher fraternity
	Lack of interest in change	Students are not learning anything new apart from syllabus	Unaware of advantages of change	Internal Assessment	Educate on the benefits of change	Teacher fraternity & Management
	Lack of awareness of market demand	Imparting teaching not required in industry	Less interaction with industry	Update education curriculum	Constantly keeping in check with latest technology	Teacher fraternity, management and technical

						council
Placements	Poor college-corporate relation	Low core companies job offers	Low skilled graduate produced	More industry based knowledge output	Industrial training and presentation	Teachers and T&P cells
	Lack of initiative from T&P cell	Poor placement records of college	No proper coordination between T&P and companies	More interaction with companies	Initiative for both core and Non-core companies	T&P cells and HR of companies
Geographic Location	Lack of Technical facilities available	Poor Research output	Lack of important lab equipment available	Immediate release of funds for purchasing necessary equipments	Try to purchase necessary equipments to carry out state of the art research	Concerned department, College administration, if required then state government
	Lack of interest by recruiters	Deserving Candidates not getting jobs	Having region disparity from the companies	Having faith that remote part of the nation can also have deserving talents	Hiring students based on their skills not on the basis from which region of the nation they have come from	Training cell of the college, Human resource department of the recruiting companies
	Lack of quality faculties	Students not getting trained by effective faculty member.	Local candidates irrespective of their credentials get preferred over deserving outsider candidate.	Hiring faculty based on their academic credentials then looking at their region of location.	Hiring faculty only on the basis academic as well as professional credentials	College administration, Human resource management department of the college

Control Phase:
The major aim of the control phase is to monitor the advantages obtained after carefully implementing the detailed FMEA in the organisation structure of the concerned higher education institute. The periodic monitoring of the continuous improvement should be thoroughly checked by plotting control charts and observe that whether they are in limit or not [8].

CONCLUSION

Based on suggestions offered by different shareholders and our own assessment regarding the existing factors leading to poor quality of education in colleges/universities, we would like to propose a new pedagogy or methodology which we found it to be useful for better learning experience:

- Teachers' beliefs, behaviours, and practices, as well as the needs of their students, are all inextricably linked to effective professional development.

- Learn to co-create new knowledge by fusing practice and research in a way that benefits everyone in the room. This is an important part of collaborative, student-centred, evidence-based professional learning.

- Keep R&D at the heart of strategic planning, and ensure that findings and outcomes are shared, celebrated, and sustained in practice on a cyclical basis within universities.
- The theoretical part of R&D is automatically included in this category, so it's important to find a way to convert the strategic vision into practical, operational structures and frameworks.

- Train and support staff as evidence or research advocates so they can broker, facilitate, and promote staff engagement with and participation in research.

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